

SOCIOECONOMIC INEQUALITIES OF CHILDHOOD OBESITY IN SOUTH AFRICA

By

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PART 1: PREAMBLE

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Dedication

I dedicate this thesis to my beloved parents, siblings and friends who have been a constant source of support and encouragement throughout my studies.

Thesis Abstract

Obesity is a public health concern in both high- and low-middle income countries. In South Africa obesity is not only limited to adults but is also evidenced in children. In order to contribute useful insights for developing effective obesity policy and programme interventions, this study assesses socioeconomic (SE) inequalities related to childhood obesity in South Africa.

Using data from the South African National Income Dynamics survey (2012), the study assesses the extent of SE inequalities in obesity using concentration index (CI). The study also assesses the determinants that underpin these inequalities using decomposition analysis of the CI.

Overall, the positive CI from the results indicates that the burden of obesity is more concentrated among the rich compared to the poor with girls having slightly greater SE inequalities compared to boys. The decomposition analysis further indicated that the determinants of these inequalities were an interplay of individual (i.e. race), household (i.e. household head characteristics) and contextual (i.e. household location) level factors. These findings suggest that there is a continuous need for surveillance of obesity in children over time across different social economic status (SES) especially in low- and middle- income countries. Finally, the results suggest that both childhood obesity and inequalities are complex issues with different underlying determinants that vary with the different SES, gender and may require coordinated policy and programmatic interventions at individual, household and contextual level.

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1 Part A: PROTOCOL

1.1 Background

Overweight and ¹obesity have become a public health problem in low and middle income countries (LMICs) especially among those whose economies are transitioning from developing to developed (de Onis et al. 2010; Ng et al. 2014). Such countries include South Africa (SA), Brazil and China (Popkin et al. 2012). In the past, the burden of obesity in LMICs has been positively associated with increasing socio-economic status (SES), suggesting that being socio-economically disadvantaged was protective against obesity (Sobal & Stunkard 1989). However, to be socio-economically disadvantaged is actually a risk factor particularly for individuals within countries experiencing economic growth accompanied by high industrialisation, globalisation, urbanisation and nutrition transition (Sobal & Stunkard 1989; McLaren 2007; Zhang & Wang 2004; Drewnowski & Popkin 1997). Therefore, it is hypothesized that as a country undergoes economic transition, the burden of obesity increases faster among the socio-economically disadvantaged compared to the more advantaged individuals (McLaren 2007; Monteiro et al. 2004). Although, economic growth is a desirable and necessary goal for developing countries, socio-economic (SE) inequalities in health contributed by obesity are likely to persist and emerge in LMICs countries in the absence of concerted national public actions to prevent obesity (Monteiro et al. 2004).

Studies have shown a positive association between obesity and devastating consequences such as non-communicable diseases (NCDs) (Lobstein et al. 2004; Abegunde et al. 2007; Mayosi et al. 2009; Alwan et al. 2010). These NCDs include: type two diabetes, cardiovascular diseases,

¹ The term obesity refers to abnormal or excessive fat accumulation which may have adverse effects on the health and well-being of the individual (World Health Organization 2015).

chronic respiratory diseases and cancer. Therefore, SE differences in obesity suggest that we should similarly expect SE inequalities in these obesity related diseases. SE inequalities in health are wrong mainly because they are an expression and a product of unjust economic, political and social institutions (Whitehead 1992). Although inequalities in health particularly infectious diseases in LMICS have received substantial attention in both public health and economics, little attention has been given to NCDs and their risk factors.

1.2 Problem Statement

South Africa (SA) has amongst the highest prevalence rates of childhood obesity in Africa (Muthuri et al. 2014; Reddy et al. 2009) and these rates are comparable to those found in HIC more than a decade ago (Armstrong et al. 2006). For example, Armstrong et al. (2008) reported that the prevalence of obesity (3.2% and 4.9% respectively for boys and girls) between 2001 and 2004 among South African children aged 6 to 13 years were similar to the prevalence rates of obese children from HICs including United States of America (1976 and 1980), Scotland (1994) and England (1994). Furthermore, this study by Armstrong et al. (2008) demonstrated that the doubling of obesity rates occurred in such a small period (6 years) of time when compared to studies from USA among children aged 12 to 19 years (13 years).

Obesity has been highlighted as a major risk factor contributing to NCDs in SA (Wu et al. 2015). Existing evidence suggests that childhood overweight and obesity are contributing to the NCDs burden in South Africa (Skaal & Pengpid 2011; Rossouw et al. 2012). In 2011, NCDs accounted for 34.4% of years lost in SA (Ataguba et al. 2015). Recently, Ataguba et al. (2011) reported an increased occurrence of NCDs among the less socio-economically privileged groups. These fast

growing trends of NCDs among the socio-economically disadvantaged are likely to strengthen or contribute to the already existing SE inequalities in health and quality of life in SA. This is owing to the recently more pronounced distribution, utilization and benefits of health services among the rich compared to the poor (Stuckler et al. 2011; Ataguba & McIntyre 2013). Moreover, research has shown the poor to suffer more from infectious diseases (mostly referred to as diseases of the poor) such as tuberculosis and HIV (Harling et al. 2008; Ataguba et al. 2011; Ataguba 2013). Inequalities in health such as these are exacerbated by income inequalities. SA faces the highest income inequality levels with a Gini coefficient² of 65 based on expenditure data (per capita excluding taxes) in the year 2011 (The world Bank 2015). According to Statistics South Africa (2014), the richest 20% of the population accounted for over 61% of consumption while the bottom 20% shared 4,5% in 2011. It is therefore of utmost importance that the developed policies aimed to reduce SE inequalities in health provide everyone equal opportunities in health and productivity. An important step towards achieving this involves generating evidence on the presence and the extent of inequality rather than relying on intuition which might be misleading (Zere & McIntyre 2003; Whitehead 1992).

Previous studies have attempted to shed light on the presence of SE inequalities in childhood obesity. With the use of race as a potent indicator of SES, Reddy et al. (2009) found higher rates of obesity among the white adolescents compared to the ³Black African, Coloured and Asians implying that having a high SES was associated with obesity. During the apartheid era, the white

² Gini coefficient measures the degree of inequality with regards to income distribution where a value of zero means perfect equality and 100 means perfect inequality (The world Bank 2015).

³ The use of the terms 'Black African', 'White', 'Coloured' and 'Asian' reflects a statutory stratification of the South African population during the apartheid era (Coovadia et al. 2009).

minority benefited from discriminatory policies (Coovadia et al. 2009). On the other hand, the majority (blacks, Asians and coloured) were limited to low quality healthcare, education and were confined to physically impoverished areas (Coovadia et al. 2009). The findings of Meko et al. (2015) further emphasized the presence of SE inequalities in obesity through the use of parents' occupation as a measure of SES. They reported a higher burden of obesity among children whose parents had graduate occupation than those with parents working as casual labourers. The same findings were seen in an earlier study carried out in the ⁴THUSA BANA project in Northwest (Kruger et al. 2006). The above findings were further supported by evidence that found a positive association of 9 or 10 years SES measures with higher Body Mass Index (BMI) (Griffiths et al. 2008). However, there have been contrasting results showing weak and inconsistent associations between BMI and SES measures among 16 year old children (Griffiths et al. 2013). In spite of the strength and direction of the association, these studies have confirmed the presence of SE inequalities in obesity among SA children.

Even though the need to measure SE inequalities for the purposes of education and advocacy between decision makers and the general public is urgent, it is not sufficient to effect sustainable change on its own (Victora et al. 2003). Development of more effective policies that unravel and quantify the contributions of SE inequalities has the capacity to identify and address the root causes of SE inequality in childhood obesity (Uthman 2009). It has been argued that results from these analyses indicate more specifically the type of policies and where resources should be directed (Uthman 2009). Concentration index (CI) is one of the methods

⁴ Transition and Health during Urbanization of South Africans; BANA, children

that has been used to quantify SE inequalities in health outcomes across a continuous measure of SES providing a single measure of SE inequality (Wagstaff et al. 1991). Such health outcomes include: childhood obesity (Walsh & Cullinan 2014) and health utilizations (Van Doorslaer et al. 2004). Moreover, the single measure can further be decomposed into separate contributions where the impact of individual level regressors on the gradient can be computed. This means that the factors which drive the SE inequality can be pinpointed.

Studies in SA such as Meko et al. 2015; Griffiths et al. 2008; Kruger et al. 2006 have clearly revealed SE inequalities in childhood obesity. However, neither of these studies quantified the extent of these inequalities using CI. In addition, none of these studies used a nationally representative dataset nor decomposed the factors that might be driving the gradient. This study aimed to fill this gap by using the recent South African National Income Dynamics Survey (SA-NIDS). However, this study will only focus on children between 2-14 years of age. Theory has suggested that SES of the environment external to the household becomes more important for children who are above 14 years of age than SES of the household (West 1997). The reason for excluding children below 2 years is discussed further in the methods section.

1.3 Justification

The SA National Department of Health 2013-2017 Strategic Plan for Prevention and Control of NCDs placed great emphasis on the need to reduce obesity and other NCDs risk factors (National Department of Health 2013). In order to formulate effective policies to reduce the prevalence of childhood obesity and overweight, policy makers require evidence of not only the prevalence but also its distribution. Thus, this study set out to identify SE population groups

that were at a risk or that had a high prevalence of obesity in order to inform and guide obesity prevention strategies. In addition, documenting existing disparities between the least and most advantaged social groups is important for monitoring trends and the effectiveness of intervention measures (Singh et al. 2010; Singh et al. 2008). The decomposition analytical technique will be used to assess enable the contribution of each determinant of obesity on SE inequality in obesity, hence providing important information for policy makers to design effective strategies to reduce SE inequalities in obesity.

1.4 Research question

To what extent do SE inequalities exist in childhood obesity in South Africa, and what underlying determinants of childhood obesity can explain these inequalities?

1.5 Objectives

This study seeks to address the following objectives

1. To quantify SE inequalities in childhood obesity;
2. To decompose the observed SE inequalities in childhood obesity into non-modifiable and modifiable determinants of obesity; and
3. To identify the most at risk groups for effective interventions.

1.6 Conceptual Framework and study conceptual Framework

The aetiology of obesity is multifaceted and complex (Conway & Rene 2004; Walsh & Cullinan 2014). Physiologically, obesity is a result of long-term imbalance between energy intake and expenditure which are influenced by biological and environmental factors (Poston & Foreyt

1999). For this reason, approaches to obesity management and prevention have mainly been behavioural, educational and pharmacological (Swinburn et al. 1999). This meant that, the solution to obesity was individual responsibility. It is important to note however, that these approaches have not been successful in decreasing the obesity epidemic despite the fact that such interventions might be helpful (Golay et al. 1996). This is because these approaches fail to address the larger SE, political and environmental forces that shape these behaviours. As a result, emerging research from Zhou & Cheah (2015); Harrist et al. (2012); Swinburn et al. (1999); Davison & Birch (2001) and Reed et al. (2011) suggested need for trans-disciplinary understanding of obesity through ecological perspective. Glanz & Rimer, (1997) asserts that the ecological perspective which encourages and highlights all the levels of influence can be used to support long-term healthful lifestyle choices. Consequently, this approach has been used in childhood obesity research and prevention efforts (Lytle 2009; Lobstein et al. 2004; Birch & Ventura 2009). Despite the growing evidence of the importance of an ecological approach to understanding obesity, there is limited research using this approach to study childhood obesity in LMICs. The ecological perspective postulates that changes in an individual outcome are not only influenced by individual level but by also other contexts in which a person is embedded in (Ohri-Vachaspati et al. 2014). The link between the individual factors and other contexts are described by United Nations International Children Emergency Fund (UNICEF) conceptual framework of child malnutrition.

The study framework (see Figure 1) recognizes that child malnutrition is a biological manifestation of immediate causes that happen at individual level which are deeply rooted in a set of underlying causes at household level and basic causes at society level (UNICEF 1990). This

framework has been applied to various studies by Silveira et al. (2014); Beatriz & González (2014) and Kamiya (2011) to tackle the issue of malnutrition although not specific to obesity. However, although the framework has been criticized for being unidirectional (Davison & Birch 2001), its strength is its flexibility, meaning its vague ecological levels permits the emergence of different causal patterns in different contexts (UNICEF 1990).

Based on the framework (figure 1), the basic causes determine how resources are distributed in the society resulting in social stratification leading to differential exposures to both underlying and immediate causes coupled with different vulnerabilities to obesity incidence, severity and subsequent social consequences. Therefore, this study is interested in determining which underlying factors are contributing to SE inequalities in obesity. These underlying factors will be categorized into individual, household and community with major focus on the last two categories.

1.6.1 Underlying factors

1.6.1.1 Education level of the caregiver

A 2008 systematic review found positive association with childhood overweight/obesity for parental education LMICs (Shrewsbury & Wardle 2008) This meant that higher level of education of the parents is associated with obesity. Education of the parent influences nutritional knowledge and income levels which in turn influence the dietary patterns (quantity and type) and sedentary lifestyles (Davison & Birch 2001; Farajian et al. 2012; Yabancı et al. 2014; Roblin 2007; Averett et al. 2014)

1.6.1.2 Food insecurity

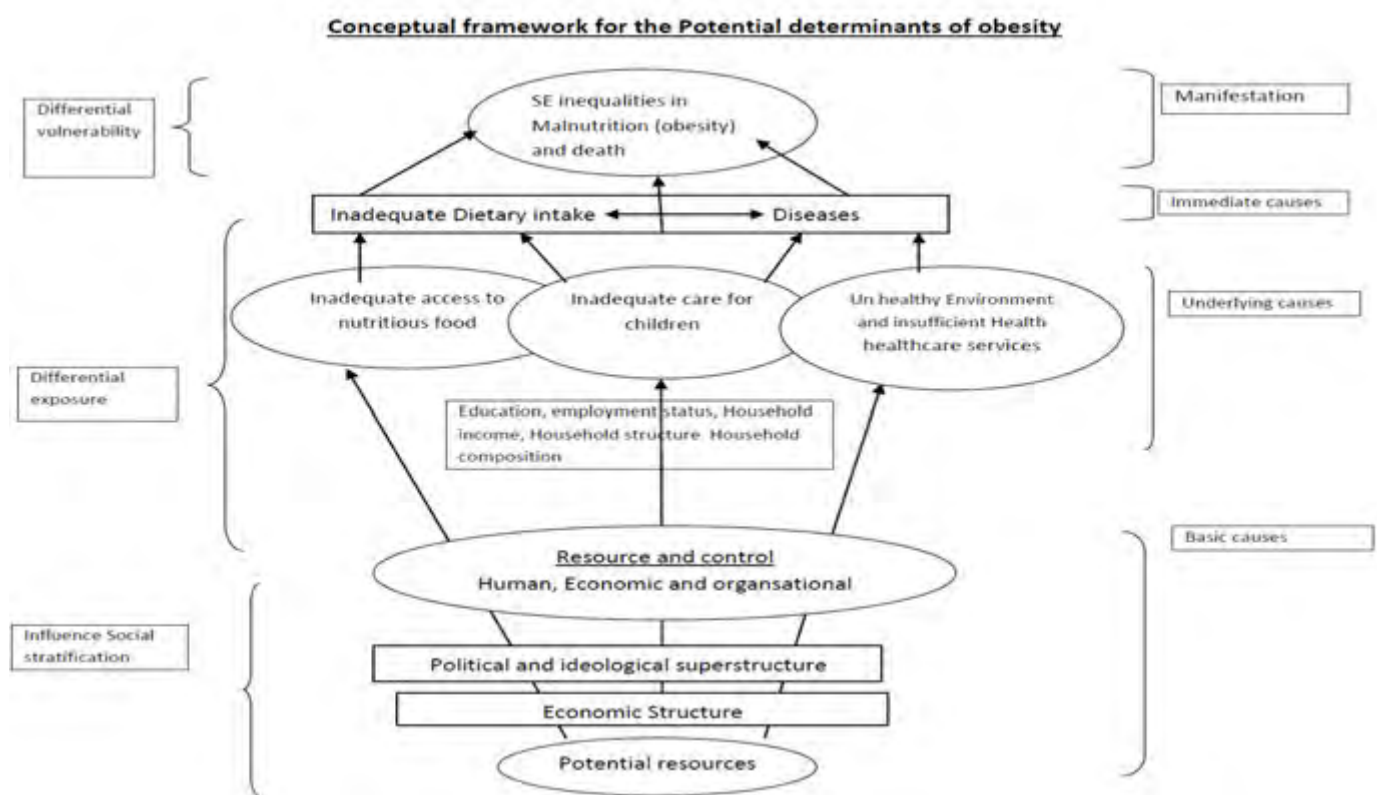
Food insecurity is termed as: unavailability and inaccessibility of nutritionally adequate and safe foods (Franklin et al. (2012). Food insecure households in high and middle income countries are often reported to be at increased risk of obesity, because healthy food is often expensive and not readily available compared to high-calorie foods that are cheaper, limited in nutrients and readily available (Tanumihardjo et al. 2007).

1.6.1.3 Environmental factors

Popkin (1994) postulates that urbanization and socioeconomic transformation increases access to energy dense foods. Therefore, it was hypothesized, that upon exposure to urban areas, traditional diets are abandoned (Bourne et al. 2002). This is because urban areas have more fast food outlets and street hawkers selling that are refined carbohydrates and fat foods (Kruger et al. 2001). Also it has been suggested that during nutrition transition healthy food is often expensive and not readily available compared to high-calorie foods that are less expensive, limited in nutrients and readily available (Tanumihardjo et al. 2007; Dinsa et al. 2012).

It is hypothesized here that these household factors (i.e. food security, employment status of the head of the household, mother's education) and community characteristics (neighborhood safety, urbanicity and province) are unequally distributed across the different SE groups thus contributing to SE inequalities in obesity.

Figure 1: Study conceptual framework



1.7 Methods and Analysis

This section provides a brief description of the dataset. It further explains in detail how childhood obesity, SES and inequality will be measured. Lastly, the section explains how the decomposition analysis will be conducted.

1.7.1 Data

The 2012 wave three SA-NIDS dataset will be used to answer the research question. This survey was carried out by the South African Labour and Development Research Unit (SALDRU). It was commissioned by the South African presidency in 2006 to monitor SE progress of individuals within different population groups. The data is a national representative panel undertaken to estimate the livelihoods of South Africans. This means that the SA-NIDS documents the dynamic structure of a sample of households in South Africa. Full details of the NIDS can be obtained from De Villiers et al. (2013). In summary, NIDS is a nationally representative longitudinal survey that uses a two-stage sampling design to sample households in nine provinces of SA. In the first stage, 400 primary sampling units (PSUs) were chosen from a Statistics South Africa master sample of about 3,000 PSUs. 10,000 households were interviewed at the end of the third wave and data were collected between April and December 2012. (De Villiers et al. 2013). Of relevance for this study, for children below 14 years, the questionnaire was answered by the mother, caregiver or household member.

1.7.2 Definition and Measurement of Childhood Obesity

Body fat measures include waist circumference, hip circumference, fat mass index, and BMI and skin-fold thickness (Cole et al. 2000). This study will use BMI because publications have found it

to be a simple and robust measure with a high correlation with other measures of adiposity (Ahrens et al. 2014). Therefore, BMI will be calculated by independently dividing the weight in kilograms by the squared height in meters. Since the BMI varies with both age and sex in children, the use of age and sex specific cut-off points for BMI is recommended. As a result, there has not been any agreement on the international definition of obesity or overweight (Cole et al. 2000). It should be noted that instead there is a general consensus that childhood obesity prevalence should be reported using several references (Rolland-Cachera 2011). The commonly used definitions of child obesity internationally are those references specified by: International Obesity Task Force (IOTF), Centres for Disease Control and Prevention (CDC), and World Health Organization (WHO) (Gonzalez-Casanova et al. 2013; Ahrens et al. 2014). This study will use the IOTF classification based on four reasons: first, it is gaining increasing acceptance, the classification method was developed from a sample of international subjects which allows global monitoring (Neovius et al. 2004), the cut-off points are not arbitrary (Cole et al. 2000) and lastly the high specificity of IOTF cut-offs is important in identifying the most worrying cases of obese children and at the same time helps to differentiate childhood obesity which is as a result of being more muscular from that occurring as a consequence of body fat (Reilly & Wilson 2006). However, this method is not without any limitations. It is only applicable to children between the ages of 2 to 19. Because we are interested in the policy implications of obesity, the latter will be measured as a binary variable with 1 indicating being obese and 0 not obese.

1.7.3 Constructing a measure of Household SES

Using CI to measure SE Inequalities requires the SES measure to be a continuous variable (Alaba & Chola 2014). For this reason, all the other measures such as education and occupation will be excluded but household income will be retained. However, collecting accurate data on income is difficult due to measurement errors arising from under-reporting, seasonality, recall bias and imputations especially in developing countries (Glewwe 1991). As a result, researchers have derived proxy measures of SES. Amongst these derived proxy measures, asset index has been used increasingly based on the following reasons: data can be easily collected, it is representative of the long term economic status, it is a convenient way of summarizing the living standards and lastly, it is useful as a control variable when estimating variables correlated with household wealth (Chuma & Molyneux 2009). The major problem with asset index is that the choice of asset variables and their weights are not grounded theoretically (Vyas & Kumaranayake 2006). Regardless of its disadvantages, studies such as Alaba & Chola 2014; Kamiya 2011; Hosseinpoor et al. 2012; and Vellakkal et al. 2013 have been increasingly adopting this approach rather than direct measures, particularly in LMICs. In this study, asset Index will be constructed using asset indicators that are grouped into household characteristics and household ownership of consumer durables. Due to lack of guidelines on how to select the range of assets to include in an index, variables will be selected on the basis of understanding of the study area, and their use in other studies (Ataguba et al. (2011); Alaba & Chola (2014); Chuma & Molyneux (2009); Vyas & Kumaranayake (2006) and Hosseinpoor et al. 2012). Therefore, the following variables will be considered when constructing the asset index:

- type of dwelling, roof, and wall material,

- access to safe drinking water, toilet, and source of energy for lighting and
- Ownership of a car, landline, cell phone, TV, and radio.

Households that did not respond will be excluded from the analysis. Furthermore, Principal Component Analysis (PCA) will be used to determine weights for an index of the asset variables. In so doing a continuous SES is created as shown in Equation one below (Filmer & Pritchett 2001). Thereafter, households will be classified into SES quintiles based on the asset score with 1 as the lowest score and 5 as the highest score). Lastly, the kernel density function of the asset index will be conducted to assess truncation and clumping⁵ (Vyas & Kumaranayake 2006).

$$A_i = \sum_k \left[f_k \frac{(a_k - \bar{a}_k)}{s_k} \right] \quad \text{Equation 1}$$

Where a_k is the value of asset k for household i , \bar{a}_k is the sample mean, s_k is the sample standard deviation, and f_k are the weights associated with the principal component

1.7.4 Measurement of SE inequality in obesity

This study will use CI to assess the extent of SE inequality in the distribution of obesity across the different SE groups. For simplicity and convenience, CI is defined as shown in equation two

$$CI = \frac{2 \text{ cov}(h_i r_i)}{\mu} \quad \text{Equation 2}$$

Where h is the health variable (for this study it is Obesity) of an individual (i), r is the ranking of SES, and μ is the mean of the health variable (Jenkins 1988). This approach requires the plotting of the enumerated population of individuals to be ranked in ascending order of SES against the

⁵ According to Vyas & Kumaranayake (2006) clumping occurs when households are grouped into clusters making it difficult to distinguish households from the asset list whereas truncation occurs when the distribution of SES is spread over a narrow range that makes it difficult to distinguish the poor and the very poor.

cumulative percentage of obesity. If the greatest proportion of obesity exists among the poorest (defined in the literature as ‘pro-poor’ inequality), a negative CI (<0) is obtained, while if the greatest proportion of obesity exists among the richest (defined as ‘pro-rich’ inequality), a positive value is computed (>0) (Wagstaff et al. 1991). The CI is bounded between -1 for perfect pro-poor inequality and +1 for perfect pro-rich inequality. Perfect equality occurs where obesity is distributed equally across the income distribution, giving a CI of 0 (Wagstaff et al. 1991).

The above equation is computed easily by the “convenient regression” approach in order to estimate both the CI and standard errors. As a result, statistical inferences can be made (Kakwani et al. 1997). This will produce *unstandardized CI*. (See equation three below)

$$2\sigma_r^2 \left(\frac{h_i}{\mu} \right) = \alpha + \beta r_i + \epsilon_i \quad \text{Equation 3}$$

Where σ_r^2 is the variance of rank of SES r , β is an estimated CI, α is the OLS estimate of the slope coefficient gives the standardized CI estimate and ϵ is the stochastic error. To account for age-sex variations, CI will be standardized indirectly by subtracting the influence of all standardizing variables from unstandardized CI (Van Doorslaer et al. 2004). Alternatively, CI can be standardized by including the standardizing variables directly into the convenient regression either for full or partial correlations of the health variable with the standardizing variables (O’Donnell et al. 2008). In this study, indirect standardization will be used which will be followed by a normalization process.

A normalization process is crucial because the health measure (obesity) is a binary variable; hence, the CI is not bound between -1 and 1. As a result, the CI is quantified between -1 to 1 by multiplying the calculated CI by $(1/1-\mu)$ (Wagstaff 2005). There have been various debates

about the appropriate normalization to be followed when using binary variables (Erreygers & Van Ourti 2011). In this study, Wagstaff normalisation will be used instead of the Erreygers method. This is because with Erreygers index, the direction of inequality does not change despite the change in magnitude of the inequality and also the fact that it is obtained from scaling which is obtained from the Wagstaff normalisation (Ataguba et al. 2011). Despite the differences, both methods have been used before and similar results were obtained (Alaba & Chola 2014).

1.7.5 Decomposition of CI

Decomposition provides clarity on both the quantification and the impact on which explanatory variables of obesity contribute to the observed SE inequalities (Van Doorslaer et al. 2004). These variables include determinants of obesity. A variable will be included in the decomposition analysis based on their impact on obesity and SES. A variable will be found to have no impact on the inequality if it has no significant impact on the dependent variable (obesity). Alternatively, the variable will not have an impact if it is evenly distributed across the income distribution. Therefore, the linear regression model linking the outcome variable y to k determinants x_k is given in Equation four below

$$y = \alpha + \sum_k \beta_k x_{ki} + \epsilon_i \quad \text{Equation 4}$$

The CI for y can be decomposed into the contributing factors which determine SE inequalities in obesity as shown in Wagstaff et al. 2003. The study demonstrated that the CI for y can be formulated as in equation five below

$$c = \sum_k \frac{(\beta_k \bar{x}_k)}{\mu} c_k + \frac{Gc_{\epsilon}}{\mu} \quad \text{Equation 5}$$

Where, μ is the mean of the health variable y which is obesity, \bar{x}_k is the mean of x_k of each regressor, c_k is the CI x_k where k refers to the regressors included in the obesity equation, and β_k is the coefficient for each of the obesity determinants. Gc_{ϵ} is the generalized CI for the error term defined as:

$$Gc_{\epsilon} = \frac{2}{n} \sum_{i=1}^n \epsilon_i r_i \quad \text{Equation 6}$$

where r_i is the fractional rank of the i th person relevant in the distribution (Wagstaff et al. 2003). The error term in Equation 5 above reflects wealth related inequality in obesity prevalence that is not explained by systematic differences in x_k across wealth groups (O'Donnell et al. 2008). This study will normalise the CI using Wagstaff's method to yield the following:

$$c_{normalised} = \frac{c}{1 - \mu} = \frac{\sum_k \left(\frac{\beta_k \bar{x}_k}{u} \right) c_k}{1 - \mu} + \frac{\frac{Gc_{\epsilon}}{\mu}}{1 - \mu} \quad \text{Equation 7}$$

The variables (see Table 1) to be used in the decomposition analysis will be based on the conceptual framework for determinants of childhood obesity (discussed above).

Table 1: variables that will be used in the decomposition analysis

Community Variables	Variable type
province	Western cape=0 (categorical) Eastern cape=1 Northern cape=2 Free state =3 Kwazulu Natal=4 Northwest=5 Gauteng=6 Mpumalanga=7 Limpopo=8
Household residence	(Binary) urban=1 Rural=0
Neighbourhood safety	Absence or infrequent occurrence of gangsters' in the neighborhood (1= absence or infrequent gangsters'; 0=otherwise
Household level variables	Variable type
Household size (number of people residing in a household >5)	Yes=0 No=1 (Binary)
Household Income	Quintile 1-0 (categorical) Quintile 2-1 Quintile 3-2 Quintile 4-3 Quintile 5-4
Employment status of head household	(Binary) Employment=0 unemployment status=1
Marital status of the child's parents	(Binary) Married or living with partner=0 single, separated, divorced, widowed=1
Care giver's level of education	No education=0 (categorical) Primary education=1 Secondary education=2 Tertiary education=3
Anyone in the household that exercises	(Binary) Yes=0, No=1
Anyone in the household that smokes	(Binary) Yes=0, No=1
child variables	Variable type
Gender	(Binary) Female=0 male=1
Age	Continuous variable
Self -reported health status of the child	(Binary) Good=0, poor=1
Race	Black Africa=0, Coloured=1, Indian/Asian=2 , White=3 (categorical)

1.7.6 Data Analysis

Data analysis and management will be done using Stata software (Stata corp. Inc., college station, Texas, USA) while analysis of inequality in health outcome will be carried out using Adept software. The Adept software was developed by the World Bank. In order to assess the difference, between quintiles in the distribution of obesity for both boys and girls, the Chi-squared (χ^2) significance tests will be used. In the decomposition analysis, the ordinary least squares method will be used. A multistage sampling procedure (clustering and stratification) was used for the SA-NIDS, hence all estimates will account for the sampling weights and adjustments will be made to the results.

1.8 Limitations of the study

A key limitation of this study is that it will be based on cross-sectional design which does not allow analysis of the cause and effect relationships. In addition, the study lacks data on likely determinants of childhood obesity such as community recreation space.

1.9 Research Ethics

This study will use secondary household survey data and so no ethical issues are expected. However, ethics approval will be obtained from the Faculty of Health Sciences' Human Research Ethics Committee of the University of Cape Town before the start of the study.

1.10 Bibliography

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2 Part B: LITERATURE REVIEW

This chapter aims to provide a literature review consisting of three sections namely: theoretical, methodological and empirical section. The chapter begins with a summary of Socio-economic (SE) inequalities and inequities in health. Subsequently, theoretical approaches for evaluating childhood nutrition, obesity and SE inequalities will then be explored. Thereafter, the different methods used to measure SE inequalities in obesity will be reviewed and concludes with a summary highlighting the gaps in published literature on SE inequalities in obesity among children. The literature search in this chapter is guided by the following research question which guides the study: To what extent do SE inequalities exist in childhood obesity in South Africa, and what underlying determinants of childhood obesity can explain these inequalities?

2.1 Theoretical review

This section is sub-divided into two sections namely, 1) SE inequalities and inequities in health and 2) the theoretical approaches for evaluating childhood nutrition, obesity and socio-economic inequalities. The literature included in this section was obtained from the following electronic databases searches: MEDLINE, ACADEMIC SEARCH PREMIER, AFRICA WIDE INFORMATION, ECONLIT, and CINAHL using the EBSCOHOST database platform. All the databases were searched and limited to the period from 2001 to the 2015 which was appropriate to cover recent literature. No literature was excluded on the basis of country of origin, and publication date except if it was not in English. The literature from electronic database searches were supplemented with both grey and website literature. Furthermore, bibliographies were hand searched of all the included literature on health inequalities.

2.1.1 Socio-economic inequalities and inequities in health

Health inequalities have been conceptualised as individual differences in health, differences in health between population groups or health differences between groups occupying unequal positions in society inequalities (Graham 2007). This study is interested in knowing how the burden of disease (obesity) is distributed across different SE groups. For this reason, the term health inequality in this study is understood as health differences between different SE groups. It is worth noting that the concept of health inequity is health inequality that is systematic, unfair/unjust and socially produced (therefore modifiable). This means that not all health inequality is unfair. Determination of what is unjust or unfair is not simple since state of knowledge, resource availability, public acceptance and ideology play a huge responsibility (Carter-Pokras & Baquet 2002).

The need to reduce the health inequalities between SE groups has strongly been articulated by a number of World Health Organisation (WHO) policy statements and papers such as WHO 1985; WHO 1986; & Whitehead 2000 (Pradhan et al. 2003). SE inequalities in health are of concern mainly because they are health inequities. This is because existence of SE inequalities in health implies failure of the society to organize health resources (social determinants of health) equitably such that access is open to everyone. Since these health inequities are socially produced, they are also regarded as avoidable or modifiable (Whitehead & Dahlgren 2006).

2.1.2 Theoretical explanations of the SE inequalities in health

Three major pathways have been advanced to explain health inequalities from the social environment. These include: social causation, social selection, and life course perspective (Solar & Irwin 2010). These three theories were first mentioned in the seminal Black Report (Blane 1985).

The social causation theory suggests that SE inequalities in health are likely to arise when the intermediary factors are unevenly distributed between the different SE groups (Solar & Irwin 2010). The intermediary factors include: material, psychosocial, behavioural, and health system factors. This theory is premised on the notion that SES influences health through intermediary factors. For example, In relation to obesity, previous work suggests that SES affects obesity by influencing the ability to purchase nutritious foods, or living in a safe neighborhood with pleasant places to exercise and markets that sell affordable nutritious food. This material hardship also could increase obesity insofar as it is a source of chronic stress; stress could limit peoples' ability to change weight-related behaviours even when informed and motivated.

According to Diderichsen framework, not only does SES lead to differential exposure to health damaging or health promoting exposures but also to differential vulnerability to incidence and severity and subsequent social consequences of illness (Braveman 2009).

In contrast to this theory, the social selection theory suggests that SE inequalities in health occur when poor health leads to social mobility such that healthier persons move towards better SES compared to the unhealthier (Canning & Bowser 2010; Blane 1985). However, literature has suggested that SES is the cause of health inequalities rather than vice versa (Link & Phelan 1995). Therefore, such evidence has consequently led some studies to conclude that social selection cannot be regarded as the predominant explanation for health inequalities (Brimblecombe et al. 2000; Power & Matthews 1997; Marmot et al. 1997). Lastly, the life course perspective posits that SE inequalities in health are a result of life processes that vary over a time (Law et al. 2007).

This study acknowledges that all three theories could possibly explain the pathway or mechanisms of health inequalities. However, because the aim of this study was to identify those determinants of obesity that are unequally and socio-economically distributed, only the social causation theory is applicable. In order to explore and understand the determinants of and socio-economic distribution of obesity in children a conceptual framework is required. The next sub-section discusses the dominant theoretical frameworks that can be used to study SE determinants of obesity in children.

2.1.3 Theoretical approaches for evaluating childhood nutrition, obesity and SE inequalities.

A variety of disciplines such as epidemiology and paediatric nutrition have demonstrated that childhood obesity results from an interaction of multiple factors rather than one cause (Gable & Lutz 2000). It has been suggested that diseases whose determinants are complex, hierarchical and interrelated should be managed through the use of conceptual frameworks (Victora et al. 1997). In the process, underestimation of the distal determinants⁶ of obesity is minimised. This section will briefly describe the key theoretical frameworks focusing on child health nutrition, starting with the earlier, individualistic and interpersonal models, followed by a more detailed description of the ecological models which were the focus of this study. Thereafter, the section will conclude with a detailed description of the present study's conceptual framework that is adapted from the ecological model.

Earlier models used in the understanding of child health nutrition include those focusing at either individual (such as health belief model) or interpersonal level (social cognitive model). However, obesity is not only influenced by individual factors such as cognitions, behaviours, and lifestyles but also physical and socio-cultural environments (Lytle 2009). As a result, emerging literature has suggested understanding obesity through ecological perspective in order to highlight all levels of influences on health lifestyle choices (Zhou & Cheah 2015; Harrist et al. 2012; Swinburn et al. 1999; Davison & Birch 2001; Reed et al. 2011).

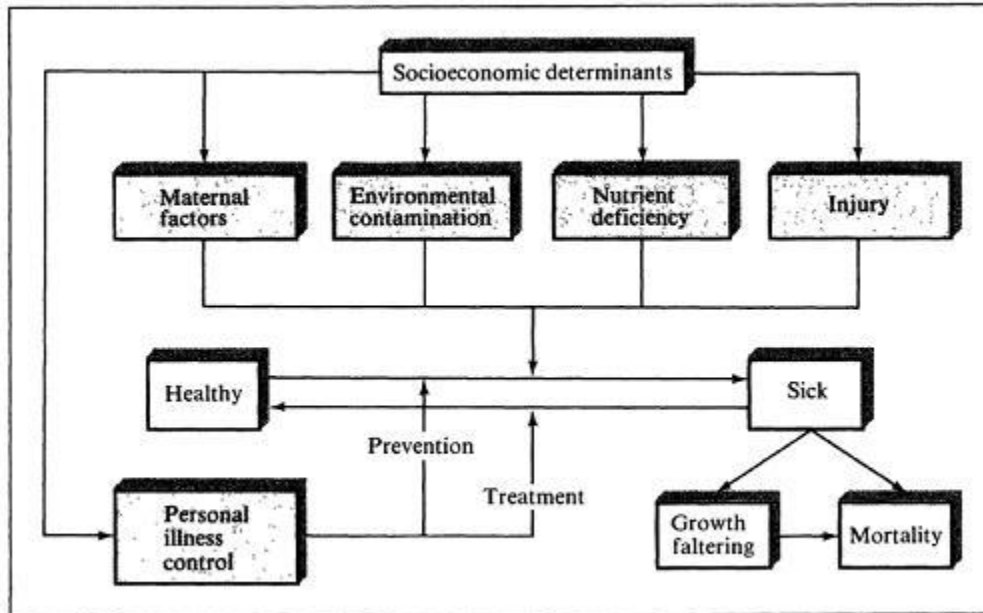
⁶ Distal determinants are those factors that indirectly influence obesity through other proximate factors. Proximate factors those that directly influence obesity. Such proximate factors include lack of physical activity and excessive intake of energy calories

Different ecological models have been proposed over the last 10 years and a vast majority of these models have a genesis in the ecological theory (Lytle 2009). This theory posits that development or change of individual health behaviours cannot be effectively explained without consideration of the context in which the person is embedded (Bronfenbrenner 1986). Ecological models have been widely applied. Examples of their application include child malnutrition (UNICEF 1990; Garcia et al. 2012), child survival (Mosley & Chen 1984) and obesity (Lytle 2009; Davison & Birch 2001; Gonzalez-Casanova et al. 2014; Story et al. 2008; Stettler 2002). The next section provides a discussion of the conceptual frameworks by Mosley & Chen 1984, UNICEF 1990, Davison & Birch 2001 & Garcia et al. 2012 which have informed the conceptual framework for the present study.

Mosley and Chen framework

The Mosley and Chen framework (Figure 1) was proposed to understand the determinants of child survival in developing countries. As shown in Figure 1, the proximate determinants of child survival are grouped into five categories: maternal factors, environmental contamination; nutrient deficiency; injuries; and personal illness control (prevention, treatment). The conceptual core of their framework was that socio-economic determinants have to operate through a set of proximate determinants that directly influence the risk of disease and the outcome of disease processes (Mosley & Chen 1984). Given that obesity is a health outcome that is less likely to have an impact on child survival, we do not use this model in this study.

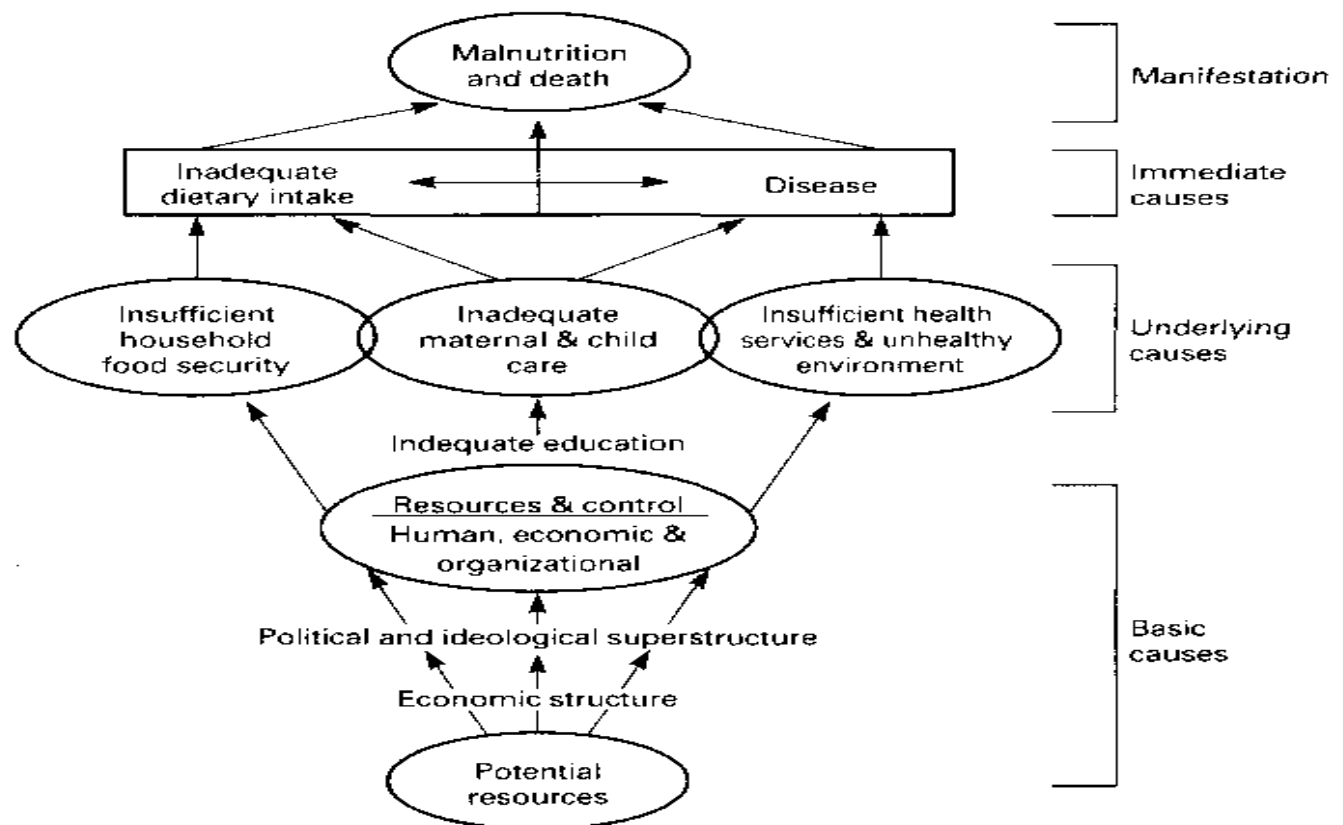
Figure 1: An analytical framework for the study of child survival in developing countries (Mosley & Chen 1984).



UNICEF Conceptual frameworks

The framework (see Figure 2) views child malnutrition and death as biological manifestation of immediate causes that happen at individual level which are deeply rooted in a set of underlying causes at household level and basic causes at society level (UNICEF 1990). This model was adapted for the present study (see part A: proposal) mainly due to its flexibility in permitting the emergence of different causal patterns in different contexts (UNICEF 1990).

Figure 2: Conceptual framework for determinants of Childhood of malnutrition (UNICEF 1990)



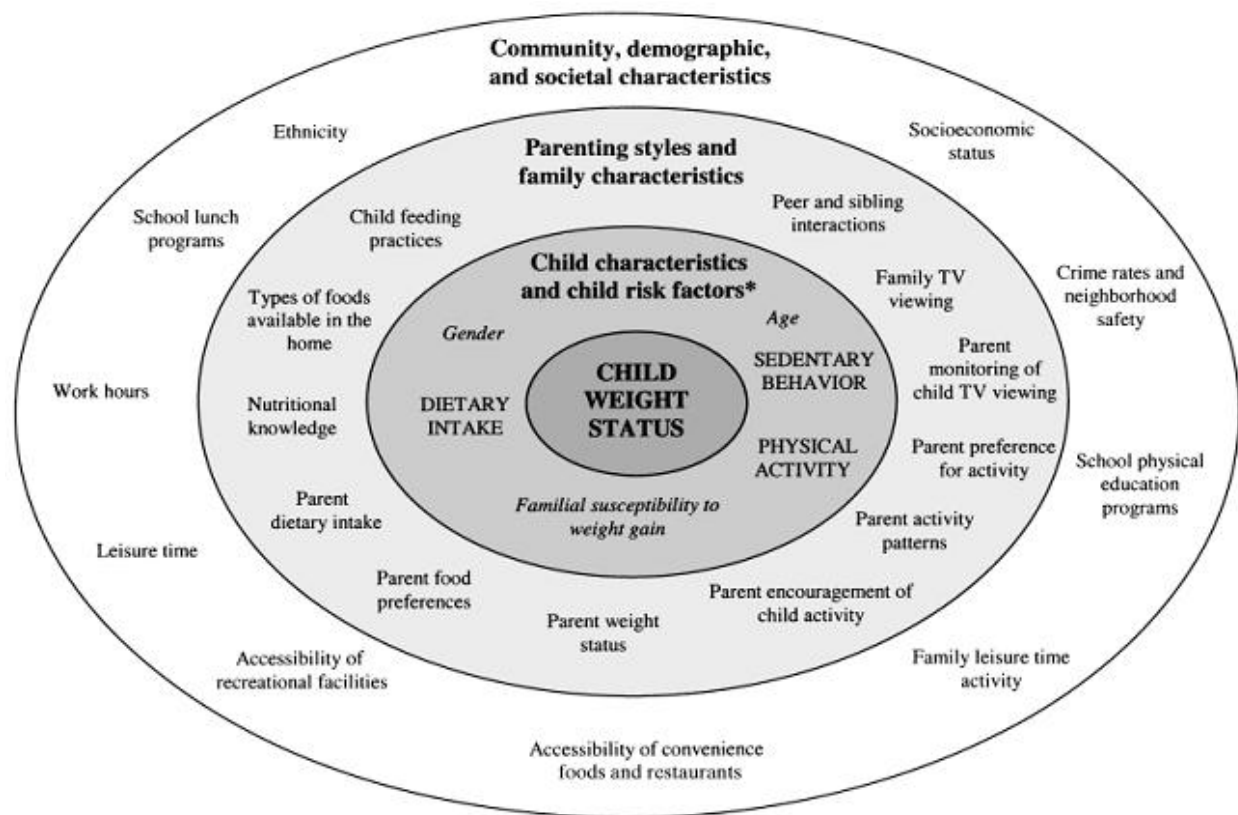
This model has been applied by studies to issues of malnutrition although not specifically to obesity (Silveira et al. 2014; Beatriz & González 2014; Kamiya 2011). The major limitation of this model is that it assumes that children in the same household are influenced by the same environmental factors, hence unidirectional in nature (Davison & Birch 2001). This is not true

because child characteristics such as age may also influence the effect the of the environment factors. For this reason, this framework was not adopted in this study.

Davison and Birch framework and Garcia et al. (2012) conceptual framework

According to the Davison & Birch (2001) (see Figure 3) it is postulated that child behavioural patterns such as dietary intake, physical activity and sedentary behaviours are “child risk factors”. These risk factors place a child at risk of obesity. In addition, this framework emphasizes that age, gender and susceptibility to weight gain moderate the impact of the risk factors on the child. Moreover, the adoption of these risk factors is influenced by both parenting styles and household characteristics which in turn are influenced by larger community and demographic characteristics (Davison & Birch 2001).

Figure 3: Conceptual framework for socio-economic determinants of childhood overweight (Davison & Birch 2001)

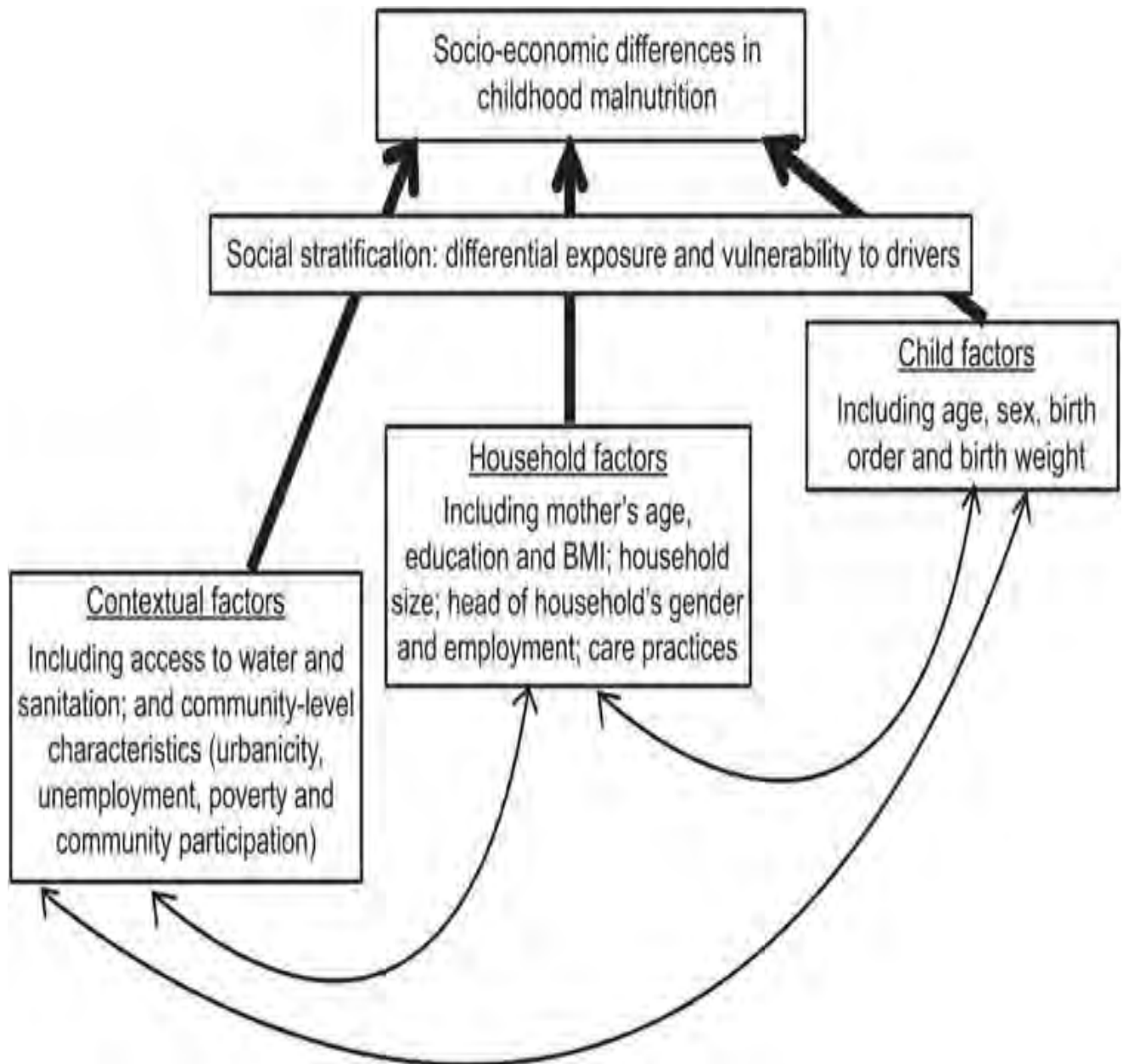


The influence of parenting styles and characteristics on the child are also dependent on child characteristics such as age, gender, weight status, time, resources and knowledge, thus bidirectional in nature (Davison & Birch 2001). Therefore, this bidirectional relationship explains why we cannot expect children in the same household to be influenced by the same environment in the same way. This study adopts the Davison & Birch (2001) model because of two reasons. Firstly, it serves as a heuristic device that not only promotes the investigation of the complex multi-factorial aetiology of childhood obesity but also facilitates the development of effective prevention programmes (Davison & Birch 2001). Secondly, it has been used widely

in a number of studies to understand determinants of childhood obesity (Garcia et al. (2012) Do et al. (2015) and Gonzalez-Casanova et al. (2014)).

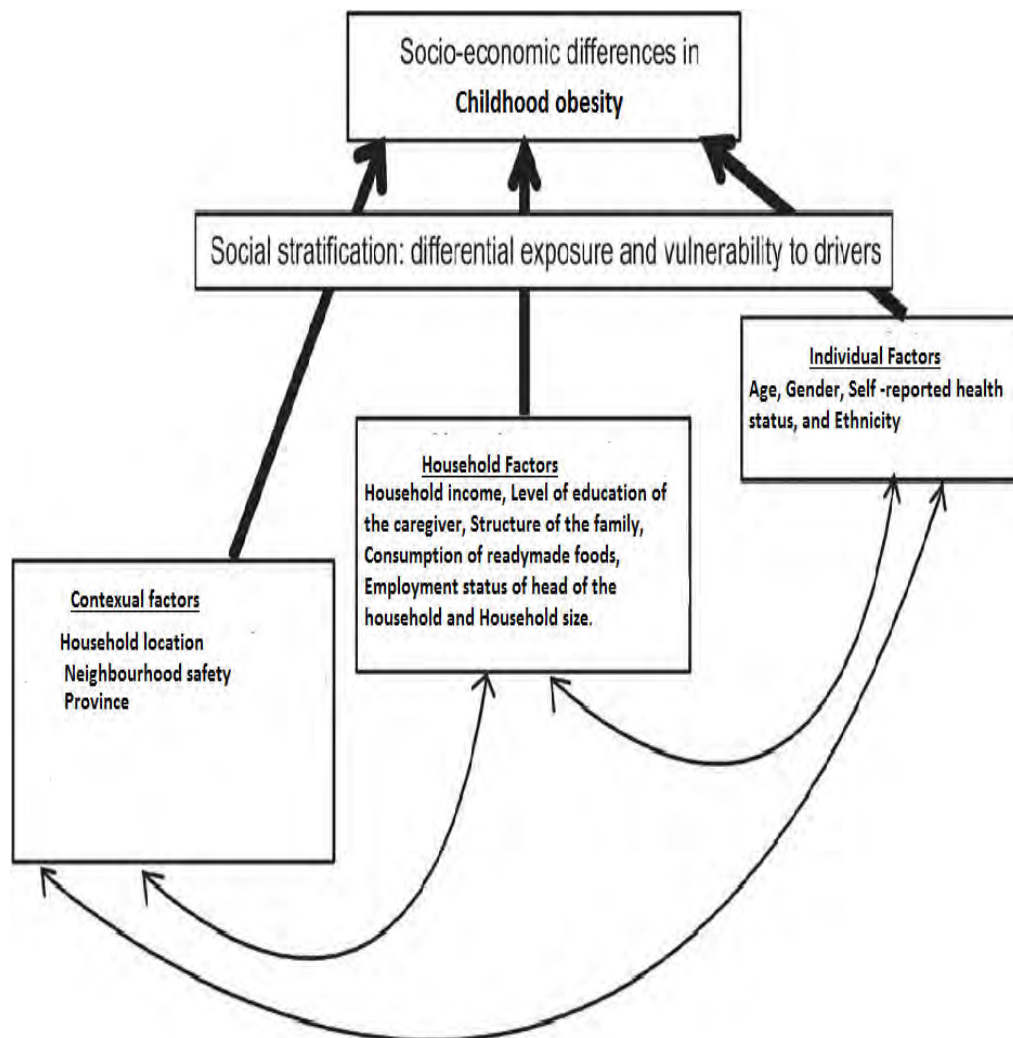
Garcia et al. (2012) draws upon Davison & Birch (2001) framework together with the Mosley & Chen (1984). The framework (Figure 4) was developed to identify determinants of SE inequalities of malnutrition among children and adolescents in Colombia. The model assumes that determinants of SE inequalities in malnutrition are as a result of unequal distribution of the determinants of obesity across SES. The framework embodies interplay of three natural categories including individual, household and community levels. This intuitive ordering is similar to the Davison & Birch (2001). The framework also allows determinants to influence each other, for example household wealth and household size. The Garcia et al. (2012) model focuses on SE inequalities which is an important aspect of this study. For this reason this study also adapted Garcia et al. (2012) frameworks to identify the determinants of socio-economic inequalities in childhood obesity.

Figure 4: Conceptual framework to identify determinants of socio-economic inequalities in malnutrition(Garcia et al. 2012)



2.1.4 Conceptual framework used in the study

Figure 5: Conceptual framework for understanding SE determinants of childhood obesity in SA



Adapted from Garcia et al. 2012 and Davison & Birch 2001)

The framework (Figure 5) posits that SE inequalities in childhood obesity arise because of the unequal distribution of the social determinants of childhood obesity across different SE groups. This framework is based on social causation theory that assumes SES to influence differential exposure and vulnerability to these social determinants of obesity resulting into their unequal distribution across different SE groups. The framework further supposes that determinants (e.g.

sex and age) influence each other. In addition, the framework advances that SE determinants of childhood obesity are interplay of different levels: individual; household and contextual. The next subsections will examine the determinants at the different levels (i.e. individual; household and contextual).

2.1.4.1 Individual factors

A wide range of literature supports the notion that obesity is as a result of a long-term imbalance between energy intake and expenditure (Karnik & Kanekar 2012; Ball & Crawford 2005; Frederick et al. 2014). This imbalance is influenced directly by diet, physical activity and sedentary behaviours of a child (Kleiser et al. 2009). Age, gender and genetics moderate the impact of the risk factors on the child (Davison & Birch 2001). In as much as genetics is among the predisposing factors to childhood obesity, the gene pool cannot evolve rapidly enough to be held accountable for the recent increase in childhood overweight and obesity (Anderson & Butcher 2006). With respect to age and gender, there is literature that suggests that boys are physically more active and fit than girls (Sallis et al. 2000; Antshel & Anderman 1999; Vilhjalmsson & Thorlindsson 1998). In relation to age, there seems to be age related decrease in physical activity, moreover this decline is faster in girls (Myers et al. 1996). For this reason this study included age and gender in the framework.

2.1.4.2 Household Factors and contextual factors

2.1.4.3 Education

An association between childhood obesity or overweight and education exists (Noh, Kim, Park, et al. 2014; Farajian et al. 2012; Keane et al. 2012; Maddah & Nikooyeh 2009). It is argued that the level of education of the parents affects the type and quantity of food served to children

through influencing the nutritional knowledge of the caregivers or household head (Davison & Birch 2001; Farajian et al. 2012; Yabancı et al. 2014; Roblin 2007). Education level of the parents may also affect their income levels (Averett et al. 2014) which in turn influences changes in dietary patterns, sedentary lifestyles and food security (Kimani-Murage et al. 2011). A review of 2008 found the positive association with childhood overweight/obesity for parental education LMICs (Shrewsbury & Wardle 2008).

2.1.4.4 Household income

Household income is positively associated with obesity or overweight (Kruger et al. 2006; Stamatakis et al. 2005; Strauss & Knight 1999) by influencing availability of food (Tanumihardjo et al. 2007), food patterns (Averett et al. 2014) and sedentary activities (Kimani-Murage et al. 2011).

2.1.4.5 Family structure

Family structure entails the physical and compositional characteristics of the family that include family size, parental involvement, emotional support which influence health behaviours (Chen & Escarce 2010). In this section we focus on two components namely: Children in households with both parents and family size.

2.1.4.5.1 Children in households with both parents

In high income countries such as Australia and United States, children raised by single parents were at risk of obesity (Gibson et al. 2007). This link is explained by challenges of time in a single parent household required to prepare nutritious foods and engage in physical activities of the child (Gibson et al. 2007; Augustine & Kimbro 2013). There is no literature to support this notion in South Africa and other LMICs.

2.1.4.5.2 Family Size

In South Africa, a study found an inverse association between family size and obesity prevalence among children between the ages of 10 to 15 years (Kruger et al. 2006). A larger household size implies that there is less food per household member consequently; they are less likely to consume more energy dense food, which are associated with obesity. (Kruger et al. 2006)

2.1.4.6 Household location

In South Africa, obesity prevalence rates were higher among urban youths than rural youths (Reddy et al. 2009; Reddy et al. 2012). It is hypothesized, that traditional diets abandonment occurs in urban areas because of availability of pre-made foods or convenience foods (Bourne et al. 2002).

2.1.4.7 Neighbourhood safety

A study found an positive association between neighbourhood homicide and obesity among preschool children from low income neighbourhood countries in New York (Lovasi et al. 2013). A safe neighbourhood is one of the factors that may influence parents to encourage and support child participation in physical activities (Davison & Birch 2001). In contrast, in unsafe neighbourhoods, parents are likely to encourage indoor activities as a proactive means of avoiding danger and protecting their children (Lovasi et al. 2013).The level of protectiveness varies for boys and girls with parents being more protective of the latter(Christensen et al. 2011).

2.2 Methodological Review

Health inequalities can be analysed as a multivariate, bivariate or univariate (Ataguba et al. 2011). Multivariate analysis compares inequality in health simultaneously in relation to at least two other variables whereas bivariate analysis compares inequality in health simultaneously in relation to a second variable such as SES (Gakidou et al. 2000; Murray et al. 1999). On the other hand, univariate analysis assesses inequality in the distribution of health in a population without reference to any other distribution (ibid). As such, the main objective of this section is to review the different methods used for measuring SE inequalities in obesity. The literature included in this section was obtained from MEDLINE, ACADEMIC SEARCH PREMIER, AFRICA WIDE INFORMATION, ECONLIT, and CINAHL using the EBSCOHOST database platform. All the databases were searched from 2001 to the 2015 which was appropriate to cover recent literature. No literature was excluded on the basis of country of origin, and publication date unless if it was not in English. The literature from electronic database searches were supplemented with both grey and website literature. Furthermore, references were hand searched of all the included literature on health inequalities.

2.2.1 Measurements of socio-economic inequalities in obesity

When studying the association between SES and obesity in public health linear and logistic regression analyses (multivariate analysis) are the traditional approaches that have been used (Zhang & Wang 2004). The direction and magnitude of the association is usually expressed as beta coefficients or odds ratios (Sobal & Stunkard 1989; Zhang & Wang 2004). The above classical approaches may help to examine the association between SES and obesity, but are insufficient in determining the severity of inequality. The other limitation is that the outcome

and explanatory variables relationship are assessed as an average but fail to account for the variability of the effect of explanatory variables across the distribution (Zhang & Wang 2004). Lastly, comparison of inequality across studies or overtime using regression is challenging. This is because the validity of regression analysis is based on the assumption of multi-normality and independence (Zeger et al. 1988).

A summary of indices have been identified in the literature to quantitatively measure the degree of income-related inequality, hence addressing the limitations of linear and logistic regression analyses. These indices include: index of dissimilarity (ID), range, Gini coefficient, a pseudo-Gini coefficient, the slope index of inequality and concentration index (Wagstaff et al. 1991; van Doorslaer et al. 1997). Among these six summary indices, Wagstaff et al. (1991) argued that concentration index and slope index of inequality are the most appropriate to measure SE inequalities in health in bivariate analysis. This is because they meet the three Wagstaff et al. (1991) basic requirements for measuring SE inequality in health namely:

1. Sensitivity to the distribution of the population across SE groups (CI and ID are consistent with the ranking units across the distribution of SES)
2. Reflection of the experiences of the population across SE groups (This means that concentration index reflects the distribution of obesity across the unequal SES of the entire population rather than just between the highest and the lowest SES)
3. Reflection of the SE dimension to inequalities in health meaning that CI and ID are consistent with the experience of health (obesity) across the distribution SES.

There seems to be an agreement that the measurement of health inequality is driven by the objectives the study intends to pursue (Mackenbach & Kunst 1997). Therefore, the present study used concentration index because:

1. It met the three basic minimal requirements for measuring SE inequality as mentioned above.
2. It provided a summary measure of SE inequality thus, enabling comparisons across demographic groups and over time
3. It is believed to have a more immediate visual appeal thus, it is easily and more intuitively interpreted (Wagstaff 1986; van Doorslaer et al. 1997).
4. It was used in decomposition analysis in order to determine the factors driving SE inequalities (Alaba & Chola 2014).

CI is not without any limitations. Firstly, CI requires at least one continuous ranking variable of SES thus limiting its applicability (Zhang & Wang 2004). However, in this study household income is used as a ranking variable (i.e. continuous variable). Secondly when measuring inequality using CI in a health outcome that is not binary the CI index is not bound -1 and 1 (Wagstaff 2005; Wagstaff 2009). This limitation led Wagstaff (2005) to propose normalisation of the binary health outcome by multiplying the calculated concentration index by $(1/1-\mu)$. However, Erreygers (2009) criticised normalisation index proposed Wagstaff based on the premise that it blows up the levels of inequality for distribution of higher income, thus proposed a normalisation index that obviates this. Lastly, literature has suggests that the

association between SES and obesity varies inconsistently across age, and sex (McLaren 2007; Sobal & Stunkard 1989). Therefore, the estimated CI without accounting for the effect of these factors on obesity will be incorrect. In order to reduce the confounding effect of age and gender, the study conducts the male and female analysis while standardising for age in both analysis.

2.3 Empirical review

This section aims to review the studies that have assessed SE inequalities in obesity so as to identify gaps in published literature as well as make sense of the findings of this study.

The studies that were included in this review were obtained from the following databases: MEDLINE, ACADEMIC SEARCH PREMIER, AFRICA WIDE INFORMATION, ECONLIT, and CINAHL using the EBSCOHOST and GOOGLE SCHOLAR platform. The search terms used include socioeconomic status or inequalities and obesity or overweight or Body mass index (BMI) or malnutrition. Other studies included were obtained from manual search on the references of the included articles. Studies were included for review if they assessed SE inequalities in obesity or overweight among children including those that assessed the association between obesity or overweight and SES. Studies that assessed SE inequalities in malnutrition among children were included because malnutrition entails a component of over nutrition or obesity. The studies included were limited from the period of 2003 to 2015. With regards to the exclusion criteria, a study was excluded if it was not written in English, if it was from high income context, if the full text article was not accessible, and if it did not focus on childhood obesity. Note: this is not a systematic review

In total 21 studies were reviewed, eight studies were from South Africa and the rest were from low middle income countries (LMIC) including China (1), Japan, Korea, Botswana, Pakistan, Mexico, Seychelles, Colombia (2), Guatemala, Nigeria, and Ghana. Amongst these studies, four studies focused on malnutrition (Zere & McIntyre 2003; Uthman 2009; Garcia et al. 2012; Novignon et al. 2015) while the rest focused on either obesity or overweight. Regression

analysis and CI were the most common methods used to measure SE inequalities among the studies included in the review.

The age of the study participants ranged from 9 to 17 years. The most commonly used anthropometric outcome was BMI in all studies, although some studies used other indicators such as fat mass index (FMI), lean mass index (LMI), weight for height, height for age and percentage of body fat (%BF). The SES indicators used included either used household SES or neighbourhood SES to represent the child SES. The first section will review the studies that assessed the association between SES and various anthropometric outcomes (detailed description see Table 1) followed by a review of studies that assessed that SE inequalities in malnutrition (Table 2)

Table 1: Summary of studies that assessed association between SES and obesity or overweight in children

Author and year	Type of study	Characteristics of the participants	Anthro-pometric outcome	SES indicator	Analytical methods	Results
Fu & George 2015)	Longitudinal study, china health and nutrition survey, 1997, 2000, 2004, and 2006, China.	1997, 2000, 2004, and 2006 N= 2,556, 2,063, 1,431 and 1,242 respectively, Age (1-8) years.	BMI	Parental years of schooling, Per capita household income, Parental state-sector employment and parental administrative job.	Longitudinal logistic regression models	Parental state sector job was positively related to child overweight/obesity in 1997 and negatively related to overweight/obesity in 2006. Household income was a significant predictor only in 2000.

Author and year	Type of study	Characteristics of the participants	Anthropometric outcome	SES indicator	Analytical methods	Results
(Kachi et al. 2015)	Cross-sectional analyses , 2010, Japan	(6–11 years: N = 397 children) (12–18 years: N= 397 adolescents)	BMI	Household income, equivalent household expenditure, parental educational attainment, and parental occupational class	Multilevel logistic regression	Adolescents living in middle-income households were more likely to be overweight than those living in high-income households (OR 2.26, 95%CI, 1.01–5.67). Similarly, adolescents living in households with low expenditure levels were more likely to be overweight than those living in households with high expenditure levels (OR 3.40, 95% CI, 1.20–9.60). In contrast, no significant association was observed among children
(Pradeilles et al. 2015)	Cross-sectional study 1990, Soweto – South Africa	N=2019 adolescents, Aged between 17-19	BMI and Percentage of Body Fat (BF)	Neighbourhood SES, Household wealth Index, and Caregiver's level of education	Binary logistic regression	SES associated with anthropometric outcomes. Furthermore, a low household wealth index was associated with lower odds of both overweight and high %BF in men.

Author and year	Type of study	Characteristics of the participants	Anthro-pometric outcome	SES indicator	Analytical methods	Results
(Meko et al. 2015)	A cross-sectional study of learners from 26 public secondary schools in Bloemfontein, 2006, Free State Province, South Africa.	N = 415, Age 13-15 year-old	BMI	Household SES based on the occupation and highest education level of the main contributor to the household.	Logistic regression analysis	No associations could be established with overweight and obesity and SES.
(Tang et al. 2015)	Cross-sectional data, China Health and Nutrition Survey, 1991-2009, China	Age (7-18 years)	BMI	Household income per capita	Logistic regression analysis	Children living in a low-income family were less likely to be overweight than those living in a high-income family
(Noh et al. 2014)	Cross sectional Korean Survey on the Obesity of Youth and Children, 2009	N= 9411, Age= 10-18 years	BMI	Subjective economic status, parental education level, parental occupational status, and family structure	Multinomial logistic regression in multivariable analysis	Low economic status was statistically significant SES risk factor in males. Similarly, high economic status was a protective factor for overweight. Among females, low maternal education level was associated with the risk of overweight

Author and year	Type of study	Characteristics of the participants	Anthropometric outcome	SES indicator	Analytical methods	Results
(Griffiths et al. 2013)	Longitudinal cohort study, 1990, Johannesburg – Soweto, South Africa.	N = 429, Age (16 year olds)	Body composition at age 16 (BMI, FMI and LMI)	Household, school, and neighbourhood SES	Multivariable regression analyses.	SES were only weakly associated with body composition at age 16, with an inconsistent direction of association. Household SES (access to sanitation and water facilities and maternal education) measured at infancy period were significantly associated with the FMI and BMI outcomes. Adolescent assessed neighbourhood and school SES measures were not significantly associated with body composition.
Kirsten et al. 2013	Cross sectional study of primary schools located in Stellenbosch, South Africa	N=45 (6-13 years)	BMI	School fees paid per annum (high, medium and low SES)	Mann-whitney u test	The prevalence of obesity was high in a higher SES. No significant association between obesity and SES.

Author and year	Type of study	Characteristics of the participants	Anthro-pometric outcome	SES indicator	Analytical methods	Results
(Reddy et al. 2012)	Cross-sectional, South African National Youth Risk Behaviour Survey in 2002 and 2000	N=9491 in 2002 and N= 9442 in 2008 Grade 11 children	BMI	School poverty level; the latter was a proxy for SES	logistic regression	Increasing SES was associated with greater risk of overweight and obesity. This pattern is evident in most of the race and gender groups.
(Wrotniak et al. 2012)	Cross-sectional, National survey, Botswana	Mean Age was 14.9 years, N=707 adolescent secondary school students (6-18 years)	BMI	Private versus public school attendance. Household assets/facilities including television, refrigerator, electricity, water and toilet	Logistic regression	Private school students and children with higher assets had significantly greater prevalence of Overweight and obesity than public school students and those with lower assets.

Author and year	Type of study	Characteristics of the participants	Anthro-pometric outcome	SES indicator	Analytical methods	Results
(Mushtaq et al. 2011)	A population-based cross-sectional study, 2010, Lahore, Pakistan	N=1860 children Aged (5-12 years)	BMI	Geographic area and monthly fee structure of the school (urban with high SES, urban with middle SES, urban with low SES and rural with low/ disadvantaged SES)	Logistic regression	Children living in the urban area with high SES were significantly at risk for being overweight and obese as compared to children living in the urban area with lower SES and rural children. Being in higher grade and living in the urban area with higher SES independently predicted the risk of being overweight.
(Kimani-Murage et al. 2011)	Cross-sectional study ,2007 Agincourt sub-district of Mpumalanga Province	N= 1848 were aged 10–20 years	BMI	Household wealth index was constructed from household assets	Linear and logistic regression analysis	Those from the highest SES households had about twofold higher odds of overweight or obesity and central obesity than those in the lower SES.

Author and year	Type of study	Characteristics of the participants	Anthro-pometric outcome	SES indicator	Analytical methods	Results
(Heidi Ullmann et al. 2011)	Cross-sectional, Mexican National Health Survey, 2000,	N= 10 069 adolescents, Age (10 to 18 years)	BMI	SES measures included maternal and paternal education, housing quality, and household assets	Multiple logistic regression	Household economic status (asset ownership and housing quality) is positively associated with adolescent obesity. High paternal education is related to lower obesity risk, whereas the association between maternal education and obesity is positive, but not always significant.
(Bovet et al. 2010)	Cross-sectional, (2004–2006), Seychelles	N=8 462 students Mean age (standard deviation, SD) of the students was 9.2 (0.4), 12.6 (0.4) and 15.3 (0.4) years in the 4th, 7th and 10th grades, respectively	BMI	SES (Type of school)	multivariate logistic	The prevalence of overweight (including obesity) was markedly higher in private than public schools

Author and year	Type of study	Characteristics of the participants	Anthropometric outcome	SES indicator	Analytical methods	Results
(McDonald et al. 2009)	Cross sectional study, Bogotá, Colombia	N= 3075 Age (5–12 years)	BMI	Ownership of household assets, neighborhood of residence, maternal education.	Multivariate binomial regression model	Ownership of household assets, neighborhood of residence was positively associated with child overweight.
(Griffiths et al. 2008)	Mixed longitudinal cohort, Johannesburg, Soweto South Africa	N=429, Age (9 or 10 years), Black children	BMI, FMI and LMI	SES birth measures, SES 9- or 10 year measures	Linear regression	Early childhood SES has a stronger association with LMI, while late childhood SES has a stronger association with FMI. This difference would not have been observed if these analyses had focused on BMI as a measure of body fat.
Groeneveld et al. 2007	cross-sectional survey, 2005, Quetzaltenango, Guatemala	N= 583 (8 to 10 years)	BMI	Type of schooling: Private schools and public schools	Mantel Haenszel common odds ratios	The prevalence of overweight (17.7% versus 10.5%, $P < 0.01$) was higher in high-SES children than in low-SES ones; the same was true for obesity (14.4% versus 2.3%, $P < 0.01$).

2.3.1 Review of the studies that assessed the association between SES and obesity or overweight

As shown in Table 1, ten cross-sectional studies found a positive association between SES and obesity or overweight meaning increasing SES is associated with increasing obesity or overweight in children (Pradeilles et al. 2015; Reddy et al. 2012; Kimani-Murage et al. 2010; Kachi et al. 2015; Tang et al. 2015; Wrotniak et al. 2012; Mushtaq et al. 2011; Heidi Ullmann et al. 2011; Bovet et al. 2010; McDonald et al. 2009). Kimani-Murage et al. (2011) suggests that this relationship observed is associated with the sedentary lifestyle and ability to afford processed foods among those in the highest SES group relative to the lowest SES group.

However, two studies found these associations to vary, and these variations are hinged on gender differences upon stratifying the regression analysis by gender (Pradeilles et al. 2015)(Noh, Kim, Oh, et al. 2014). Moreover, this association between SES and the anthropometric outcome between the different genders varied by SES indicator. For instance, Pradeilles et al. (2015) found household SES to be associated with BMI and percentage body fat rather than neighbourhood SES in men whereas among women no association was found with either SES indicators. These findings led Pradeilles et al. (2015) to suggest that the shift of overweight from high to low household SEP groups has not begun among South African adolescent men. Furthermore, the lack of significant associations or weak associations between neighbourhood SES and anthropometric outcomes in both genders could be partly because the neighbourhoods do not vary enough to capture SE related inequalities or the tool used to measure neighbourhood SE deprivation. On the other hand, Noh et al. (2014) found low self-reported economic status among males and low maternal education among females to be

associated with overweight. Various factors that could have influenced the overestimation and underestimation of the above association include; self-reported height and weight and failure to provide a detailed classification employment situation rather employed versus not employed (Noh, Kim, Oh, et al. 2014).

On the other hand, Meko et al. (2015) and Kirsten et al. 2013) found no association between SES and overweight or obesity. The probable reason for these results is the SES indicator used. This is because Shrewsbury & Wardle (2008) highlighted that the association between SES and obesity depends on the SES Indicators. Griffiths et al. (2008) added that the association between SES and obesity or overweight depends on the anthropometric indicator. This was based on the study conducted in SA that found no association between SES and LMI but not FMI and BMI but rather between SES and FMI (Griffiths et al. 2008). Therefore, the lack of association could have been because of the anthropometric outcome (BMI) used in the study. Other reasons include; different context (Bloemfontein), sample size and the age category (13 to 15 years) when compared to the three studies aforementioned.

Among the longitudinal studies, the association between SES and the anthropometric indicator exists (Griffiths et al. 2008; Griffiths et al. 2013; Fu & George 2015). However, weak associations were found between SES and anthropometric indicators among 16 year olds (Griffiths et al. 2013). This is because among the different SES indicators used only SES indicators measured at infancy were associated with FM and BMI. For example at age 16 years, those born to mothers with post-secondary school education compared to lower levels of education were associated with higher values of FM and BMI. Griffiths et al. (2013) postulates that these educated

mothers may have provided a more calorie dense diet, resulting in increased FM and BMI for their offspring. This argument is based on the premise that health messages and knowledge regarding obesity were limited even for educated individuals during the time era of the birth of the cohort. However, Griffiths et al. (2008) found infancy SES measures were only positively associated with LMI but not FMI and BMI among South African 9–10 year olds. In addition, they also found 9 to 10 SES measures to be positively associated FMI. The differences between the results of the two studies could mainly be due to the different age categories considered in both studies. In support of the above findings, Fu & George (2015), found the association between obesity /overweight and SES overtime to be greatly influenced by the type of SES indicator used at that particular time period.

Table 2: Summary of studies that assessed SE inequalities in malnutrition

Author and year	Type of study	Characteristics of the participants	Anthro-pometric outcome	SES indicator	Analytical methods	Results
(Zere & McIntyre 2003)	Cross-sectional Living Standards Survey, South Africa	N=3765 children below the age of five.	Weigh-for height height-for-age, weight-for-age.	Household expenditure	CI	Pro-rich inequalities in the distribution of child malnutrition. These inequalities were highest among coloured children and children living in metropolitan areas.
(Uthman 2009)	Nigerian demographic and Health survey (2003)	N=4187 children aged from 0 to 59 months	Child malnutrition measured as stunting	Household assets measured by principal component analysis	CI	The burden of child malnutrition is concentrated among the poor compared to the rich. Household economic status, health service index, maternal education and poor sanitation where the greatest contributors towards SE inequality in malnutrition.
(Novignon et al. 2015)	Cross-sectional data survey (Ghana)	N= children aged 0-5 years	Weigh-for height height-for-age, weight-for-age	Household assets	CI and decomposition analysis	Concentration index show that child malnutrition is concentrated among the poor. The decomposition analysis suggests that mother's education of antenatal care, health insurance and household wealth status were significant contributors to inequality

Author and year	Type of study	Characteristics of the participants	Anthro-pometric outcome	SES indicator	Analytical methods	Results
(Garcia et al. 2012)	Cross-sectional data from the Colombian Demographic and Health Survey, 2005, Colombia	N=30 779 children , Age (<18 years of age living with their mothers)	BMI	Household assets	multilevel Poisson models	Socio-economic differences for overweight were also significant, but against children in the richest quintile 14% and 32% of socio-economic disparities in overweight were explained by maternal and household characteristics

2.3.2 Review of the studies that assessed SE inequalities in malnutrition

Among the studies that assessed SE inequalities in malnutrition as shown in Table 2, only one study included overweight as an aspect of malnutrition (Garcia et al. 2012). This study found that SE inequalities in overweight were against children of high SES whereas SE inequalities in under nutrition were against the children of low SES. Other studies (Zere & McIntyre 2003; Uthman 2009; Novignon et al. 2015) found SE inequalities in malnutrition are against the poor because they focused on the under nutrition aspect of malnutrition. The two studies (Garcia et al. 2012; Novignon et al. 2015; Uthman 2009) that attempted to identify the determinants of these inequalities both discovered that maternal and household characteristics were significant contributors to inequality.

2.3.3 Synthesis of the results (Table 1 and 2)

These studies suggest the following. Firstly SE inequalities in obesity or overweight exist among South African children and also among children in other LMIC. Secondly, these inequalities are likely to be pro-rich (meaning the burden of obesity is concentrated among those with a higher SES) and there is a reversal of the social gradient. Furthermore, the studies (although few) suggest that SE inequalities in obesity vary by gender and age. With respect to age, one study concluded that these inequalities among 16 year olds and adolescents are rare (Griffiths et al. 2013). On the other hand, a study found SE inequalities among children of 9 or 10 years of age. These findings support West (1997) theory that states that SES of the environment external to the household becomes more important for children who are above 14 years of age than SES of the household.

The two studies that assessed the extent of these inequalities between boys and girls, suggest a need for further research by gender, although we cannot make conclusions based two studies. Lastly, none of the above studies assessed the determinants SE inequalities in childhood obesity.

2.4 Conclusion

Childhood obesity is becoming a public health concern in LMIC and South Africa is not an exception. Evidence suggests that the prevalence rates of obesity in South Africa are still rising moreover at faster rate compared to developed countries ten years ago. As a result, there is need to reduce the burden of childhood obesity mainly because it is positively associated with devastating health and economic consequences. Therefore, there is need to understand the determinants and distribution of obesity across the different population groups in order to develop policies that effectively reduce the burden of obesity. The various studies reviewed have shown presence of SE inequalities in obesity. Moreover these inequalities are against those children from high SES with limited studies stratifying the analysis by gender. CI is not a popular method compared to regression analysis method in the analysis of SE inequalities in obesity among the studies reviewed despite the fact the index can be decomposed further to identify the determinants of SE inequalities. Limited studies have assessed the determinants of SE inequalities as they are limited to malnutrition but not obesity. It is against this background that this study aimed SE inequalities in obesity among South Africa children using CI and identify the determinants of these inequalities based on the developed Conceptual framework.

The study was formulated on the Garcia et al. (2012) conceptual framework because it postulates that SE inequalities in childhood malnutrition arise because of the unequal distribution of the social determinants of childhood malnutrition across different SE groups. However, owing to the focus of this study's focus being obesity in lieu of malnutrition, the study also relied on the Davison & Birch (Davison & Birch 2001) framework in order to identify the determinants of obesity among children.

2.5 Bibliography

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3 Part C: JOURNAL MANUSCRIPT

Proposed journal: International Journal for equity in Health⁷

⁷ Instructions for authors appear in the appendix

Decomposing Socio-economic Inequalities in Obesity among South African Children

Brenda Nakimuli⁸

3.1 Abstract

Background: South Africa (SA) has one of the highest child obesity rates in Africa. Childhood obesity is associated with non-communicable diseases (NCDs), which have become a significant public health challenge in SA. The analysis of socio-economic (SE) inequalities related to childhood obesity may contribute useful insights for developing effective obesity policy and programme interventions. This study assessed SE inequalities related to childhood obesity in SA.

Methods: This study used data of 9181 children from the 2012 South African National Income Dynamic Survey (SA-NIDS). Concentration index (CI) was estimated to quantify SE inequalities in childhood obesity. Decomposition analysis of CI was conducted to identify determinants that underpin these inequalities at individual, household and contextual level.

Results: Overall, the findings show that obesity was highest in the wealthiest quintile (12.78%) compared to other quintiles with the poorest quintile being 7.98%. Interestingly, the burden of obesity was higher in the second quintile (lower SES) compared to the third and fourth quintiles. Across all quintiles, the burden of obesity was higher in girls (CI=0.0836) compared to boys (CI=0.0376). The results of the decomposition analysis suggest that the main contributors to inequality in both boys and girls are household-level variables, the most being the

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employment status of the household head. SES was the main contributor to SE inequality in obesity among boys followed by race (i.e. Coloured), and age whereas amongst girls, household location (i.e. urban region) and race (i.e. Black Africa) were the main contributors.

Conclusion: The results suggest that there is continuous need for surveillance of obesity epidemic over time across SES especially in LMICs. Finally, the findings suggest that both childhood obesity prevalence and inequalities are complex issues that require coordinated policy and programmatic interventions at individual, household and contextual level. For instance, at Individual level the results of this study suggest the need for gender sensitive interventions that take into consideration racial differences in curbing the rising problem of child obesity. However, further longitudinal research is required before implementation of these suggestions.

Key words: childhood obesity; SE inequality; concentration index; decomposition; South Africa

3.2 Background

Obesity is a public health concern in both high income countries (HICs) and low middle income countries (LMICs) (1). In South Africa (SA), approximately 24% of the adults are now obese (2) with recent evidence suggesting that the prevalence rates are increasing (3). Of further concern, SA has amongst the highest child obesity rates in Africa (4,5) which are comparable to those found in HICs more than a decade ago (6). Evidence in support of this shows that the prevalence of obesity (3.2% and 4.9% respectively for boys and girls) between 2001 and 2004 among South African children aged 6 to 13 years were similar to the prevalence rates of obese children from HICs including United States of America (1976 and 1980), Scotland (1994) and England (1994) (7). The high obesity prevalence rates are concerning because obesity is positively associated with non-communicable diseases (NCDs) such as, type two diabetes, cardiovascular diseases, chronic respiratory diseases and cancer (8–11) which are increasingly becoming a public health concern in SA (12,13).

Global evidence indicates that childhood obesity is unequally distributed within countries across different SE groups such as ethnicity (5), gender (14) although this study focuses on SES. In HICs an inverse relationship has been observed between childhood obesity and SES (15,16). In contrast, childhood obesity is associated with higher SES in LMIC (17). In SA, few studies have investigated the relationship between household or neighbourhood SES and anthropometric outcomes such as body mass index (BMI), obesity or overweight, fat mass and lean body mass among children. Among these studies, five found a positive association between obesity and SES (21–23,17,25) although one study found no significant association (21). In contrast, weak and inconsistent associations between BMI and SES were found among 16 year olds (23). Regardless

of the direction or strength of the association, these studies have showed the presence of SE inequalities in obesity among SA children.

Despite the fact that measuring SE inequalities provides information for education, and advocacy among the general public and decision makers, these measures may not be sufficient to bring about a sustainable change on their own (24). Therefore, for more effective policies to be developed, unraveling and quantifying the determinants of SE inequalities in health is recommended (25). It has been argued that results from these analyses indicate more specifically the root causes of SE inequality in childhood obesity and allow for more specific targeting of policies and resources (25).

Concentration Index (CI) is a method that has been widely (25–32) used to quantify SE inequalities in health outcomes across a continuous measure of SES providing a single measure of SE inequality (33). This single measure of SE inequality can be decomposed to further understand the determinants of obesity contributing to the SE inequalities (30). In SA, the only study that has attempted to unravel and quantify the determinants of SE inequalities in obesity was among adults (2) and not children. To inform policy on obesity reduction, this study aims to quantify SE inequalities in childhood obesity using CI and decompose these inequalities to understand the underlying determinants of obesity using SA-NIDS nationally representative survey of 2012.

To conceptualise and identify the determinants of SE inequalities related to childhood obesity, this paper drew significantly on the frameworks developed by Davison & Birch (34) and Garcia. et al (35). The study draws on the Garcia. et al (35) framework because it postulates that SE

inequalities in childhood malnutrition arise because of the unequal distribution of the social determinants of childhood malnutrition across different socio-economic groups. However, since the focus of this study was malnutrition and not obesity, the study also relied on the Davison & Birch (34) framework to identify the determinants of obesity among children. Both frameworks understand nutritional status to result from the interplay between proximate (individual factors such as age, gender), household (income, household size, education attainment), and community level (household location, neighborhood safety).

The study also drew on empirical literature particularly from SA to identify the determinants of SE inequalities related to childhood obesity. Empirical evidence indicates that race is associated with obesity in children in SA. Among South African children being ¹White increased the odds of being obese compared to other race groups (i.e. Black African, Asian and Coloured) (5,18). While education level of the caregiver or head of household, influences nutrition status of the child through knowledge of a healthy diet and of harmful effects of over nutrition, it affects income levels which may in turn influence sedentary lifestyle, availability of food and dietary change (14,20). Household income helps to overcome financial barriers for food availability specifically high calorie foods that are associated with obesity (27). Similarly, the link between childhood obesity and urban areas has been mediated through highly available fast-food outlets and energy-dense food products where activity is discouraged by the availability of indoor recreation and travelling by vehicle (18).

The conceptual framework adopted in this study recognized that childhood obesity is as a result of long-term imbalance between energy intake and expenditure which is influenced directly by

individual lifestyles such as sedentary behaviour, dietary and physical activity patterns (36,37). The impact of these individual lifestyles is greatly influenced and shaped by interplay of factors at individual, household and contextual levels. The framework adopted allows determinants (e.g. age and sex) to influence each other. The study sought to quantify the extent to which factors at individual, household and contextual levels, particularly those which are modifiable, account for SE inequalities in obesity of South African children. In so doing, the study aimed to identify the areas where policy may be most effectively directed to reduce inequality and obesity.

3.3 Method

3.3.1 Data source

Data used in this study came from the SA-NIDS conducted after every two years by the South African Labour and Development Research Unit (SALDRU). The SA-NIDS is a nationally representative longitudinal survey designed to assess multiple aspects of household welfare and behaviour over time. Therefore, it provides a rich and reliable source of data which includes anthropometric measures and SE indicators. In this study only one wave of the longitudinal data was analysed hence, cross sectional study. For children below 14 years, the child questionnaire was answered by the mother, caregiver or a household member. The household questionnaire was answered by the oldest woman in the household. Full details of the NIDs can be obtained at (38). In summary, SA-NIDs used a stratified two-stage cluster sampling design to sample households in all nine provinces of SA. In the first stage, 400 primary sampling units (PSUs) were chosen from a Statistics South Africa master sample of about 3,000 PSUs. The PSUs are derived from 2001 census enumeration areas and comprise of the first

sampling units from which households or dwellings are selected. In the second stage households within each PSU were selected. 10,000 households were interviewed at the end of the third wave and data were collected between April and December 2012.

The NIDS panel data was subjected to the attrition mainly as a result of household non-response. For example, the third wave attrition rate was 15.9% (38). Attrition may affect the estimates of the study, but instead sampling weights have been adjusted to solve this problem (38). In total, there were 10,824 children in the SA-NIDS (2012). However, this paper used a sample size of 9181 children (2 to 14 years). 1643 (15.179%) children were dropped from 10,824 because they either had missing variables for height, weight and gender. However, dropping the missing variables did not affect the results of the study.

3.3.2 Outcome measurement: obesity

Among children, there has not been any agreement on the international definition of obesity since BMI varies with both age and sex (39). As a result, different reference systems have been derived to define obesity. The commonly used definitions of child obesity or overweight internationally, are those references specified by IOTF, Centers for Disease Control and Prevention (CDC), and World Health Organization (WHO) (40,41). In this study, IOFT cut-offs were used because of its high specificity which is necessary in identifying the most worrying cases of obese children (42). However, the IOFT cut-offs are restricted to ages between 2-19 (39): Therefore, children below the age of two years were eliminated. In order to apply the IOFT cut-offs, estimation of BMI is required. BMI is defined as a person's weight in kilograms divided by the square of height in meters (2). Height and body weight of the children were objectively measured during the SA-NIDS, thereby allowing more precise measurements of BMI to be

computed. Because the focus of this study is obesity, the outcome variable was measured as a binary variable with (1) obese and (0) not obese.

3.3.3 Constructing a measure of socio-economic status

Quantifying SE inequalities in health using CI requires the SES measure to be a continuous variable. Therefore, income or proxies of income (such as consumption or expenditure and composite measures) are recommended (43). However, collecting accurate data on either income or consumption is difficult due to measurement errors arising from under-reporting, seasonality, recall bias and imputations especially in developing countries (44). As a result, researchers have derived proxy measures of SES ranging from single indicators such as education to more complex measures such as asset indices (45). Amongst these derived proxy measures, asset index has been used increasingly based upon the following reasons: data can be easily collected, it is representative of the long-term economic status, it is a convenient way of summarizing the living standards and lastly it is useful as a control variable when estimating variables correlated with household wealth (43). The major problem with asset index is that the choice of asset variables and their weights are not grounded theoretically (45). Although household income as a measure of SES is failure to reflect longer-run household wealth or living standards (45), this study used it as a proxy of SES. This is because income variable in the SA-NIDs datasets has been used as a reliable measure in a number of studies to calculate income inequality (27,46).

3.3.4 Measurement of socio-economic inequality

SE inequality in childhood obesity was measured using the illness concentration index (CI) proposed by Wagstaff (33). For simplicity and convenience, concentration index is computed as shown in Equation producing unstandardized CI.

$$CI = \frac{2 \text{ cov}(h_i, r_i)}{\mu} \quad \text{Equation 1}$$

Where h_i and r_i are respectively, the health status (being obese or not) of the i th individual and the fractional rank of the i th individual in terms of household SES; μ was the mean of the proportion h of the sample and cov denotes the weighted covariance.

Indirect standardization was used to account for the age and sex variations by running a simple ordinary least squares (OLS) regression as shown in Equation 2 and obtaining a concentration index (β) that measured the inequality in obesity that are systematically associated with SES.

$$2\sigma_r^2\left(\frac{h_i}{\mu}\right) = \alpha + \beta_k r_i + \sum_j \varphi_j x_{ij} + \epsilon_i \quad \text{Equation 2}$$

Where x_j are cofounding variables (age and sex in this case), σ_r^2 is the variance of the rank of SES measure, and α are parameter vectors and ϵ_i was the stochastic error term (47,48). In theory, concentration index lies between -1 and +1; where a value of -1 means that the value of ill health (obesity) was concentrated among the most socio-economically disadvantaged person while +1 value indicates that obesity was concentrated among the most socio-economically advantaged. However, it should be noted that if the outcome variable is binary as it was in this study, the concentration index was lie between $\mu-1$ and $1-\mu$ for large samples. This suggested

the need for normalization process to ensure that the CI is quantified in the range of -1 to 1 for any given health outcome. The Wagstaff normalization(49) involved multiplying the calculated CI by $(1/1 - \mu)$. However, Erreygers (50) noted that Wagstaff normalization blows up the levels of measured inequality for distribution with high or low means hence proposed Erreygers normalization. Despite the criticisms raised by Erreygers (50), this study adopts Wagstaff normalization. This was because similar results were obtained using both methods of normalization (2).

3.3.5 Explaining Inequality: Decomposition by CI

In order to assess the relative contributions of the determinants of obesity on SE inequality in obesity, the CI was further decomposed using the Wagstaff and van Doorslaer methodology (30). This method required transformation of the binary obesity measure into a continuous variable by using the ordinary least square predictions of a linear probability model (LPM) shown in Equation 3 below. The reason behind this transformation was that this type of decomposition relied on the linearity of the underlying regression model. In the study, LPM was opted for rather than non-linear logit model (most appropriate) despite the fact its estimations may be less robust and precise (48). This was because LPM provided consistent estimations on the grounds that linearity in parameters was a useful property for this study (29,51)

$$h_i = \alpha + \sum_k \beta_k x_{ki} + \epsilon_i \quad \text{Equation 3}$$

The CI for h_i was written as follows to include elasticities and inequalities of the various determinants as shown in Equation 4 below (48).

$$CI = \sum_k \frac{(\beta_k \bar{x}_k)}{\mu} c_k + \frac{Gc_\epsilon}{\mu} \quad \text{Equation 4}$$

Where, \bar{x}_k was the mean of x_k of each regressors, c_k was the CI of x_k where k referred to the regressors included in the obesity equation, x_k was a set of exogenous determinants of obesity and β_k was the coefficient for each of the obesity determinants Gc_ϵ was the generalized CI for the error. The component $\frac{(\beta_k \bar{x}_k)}{\mu}$ was defined as elasticity of h with respect to r_k and measured the impact of each covariate on obesity. Furthermore, Wagstaff normalization was also applied to the decomposition.

3.4 Analysis

Data analysis and management was carried out using Stata software version 14 (Stata corp. Inc., college station, Texas, USA) while analysis of inequality in obesity was conducted using Adept software (52) . In order to assess the difference, between quintiles in the distribution of obesity for both boys and girls, the Chi-squared (χ^2) significance test was used. In the decomposition analysis, the ordinary least squares method was used. The estimates from analysis accounted for the sampling weights and adjustments will be made to the results.

3.5 Results

3.5.1 Descriptive statistics

Table 1 below shows the descriptive statistics and the definition of variables by for a sample of girls and boys. The average age of children in the 2012 NIDS survey was approximately 7.8 years and majority of the population was African/Black (87.89%). Two thirds (68%) of the children had either a mother or father as caregivers (68.07%).), however only 32.96% of the children

lived in homes where both parents lived together. Most caregivers who had at least attained secondary education were parents as compared to other types of caregivers (that is grandparents, uncles and aunties). Furthermore, the household head characteristics show that the majority of the household heads are females (73.05%) and not married (73.04%) with few of them being employed (35.05%). With respect to contextual factors, three-fifth of the children included in the analysis was located in the rural areas. Interestingly, only 28.72% households reported that they considered their neighborhoods safe (indicated by absence or infrequent occurrence of gangsters' in the neighborhood). The proportions of the respondents were mostly from Kwazulu-Natal (33.92%), Eastern Cape (12.23%), and Limpopo (10.78%). The following provinces had the least number of respondents: Western Cape (8.91%), Northern Cape (6.52%), North West (6.49%), Gauteng (7.98%), and Mpumalanga (7.72%).

The overall prevalence of obesity among children aged 2 to 14 years in 2012 was 8.26%, with a slightly higher proportion among girls (8.69%) than boys (7.26%).

Table 1: Summary description of variables

Variable	Description	Mean/percentage		
Individual Factors relating to child				
Sex	Binary variable (0= report female child; 1=male child)	Male 49.90%	Female 50.10%	Total 9181
Age	Age in years (continuous variable)	7.84	7.88	7.86 (SD=3.72)
Obesity	Obese (1=obese ; 0=otherwise)	7.86%	8.65%	8.26%
Race	<u>Consist of four variables</u>			
	Black African (1=Yes; 0=No)	89.09%	87.28%	86.69%
	Coloured (1=Yes; 0=No)	12.12%	11.22%	11.67%
	Asian/Indian(1=Yes; 0=No)	0.55%	0.46%	0.50%
	White (1=Yes; 0=No)	1.24%	1.04%	1.14%
Illness status	Self -reported illness for at least three days in the past 30 days (1= reported illness/ injury; 0=otherwise)	4.43%	5.28%	4.86%
Household Factors				
Household monthly income	Continuous variable	5300.25	5536.38	5418.56 (SD=9241.40)
Family structure	<u>Consists of two variables</u>			
	Parents of the child are still together (1=parents of the child are together; 0=otherwise)	33.12%	32.80%	32.96%
	Number of household residents: A continuous variable	6.73	6.87	6.80 (SD=3.64)
Caregiver characteristics				
Caregiver of the child	<u>Consist of three categories</u>			
	Caregiver is either mother or father (1=Yes; 0=No)	67.54%	68.59%	68.07%
	Caregiver is grandmother (1=yes; 0=No)	21.81%	21.00%	21.21%
	Caregiver is none of the above (1=yes; 0=No)	10.63%	10.39%	10.51%
Educational level of caregiver	<u>Consists of three variable</u>			
	Mothers/fathers at least attained secondary education (1=yes; 0=No)	55.68%	57.30%	56.49%

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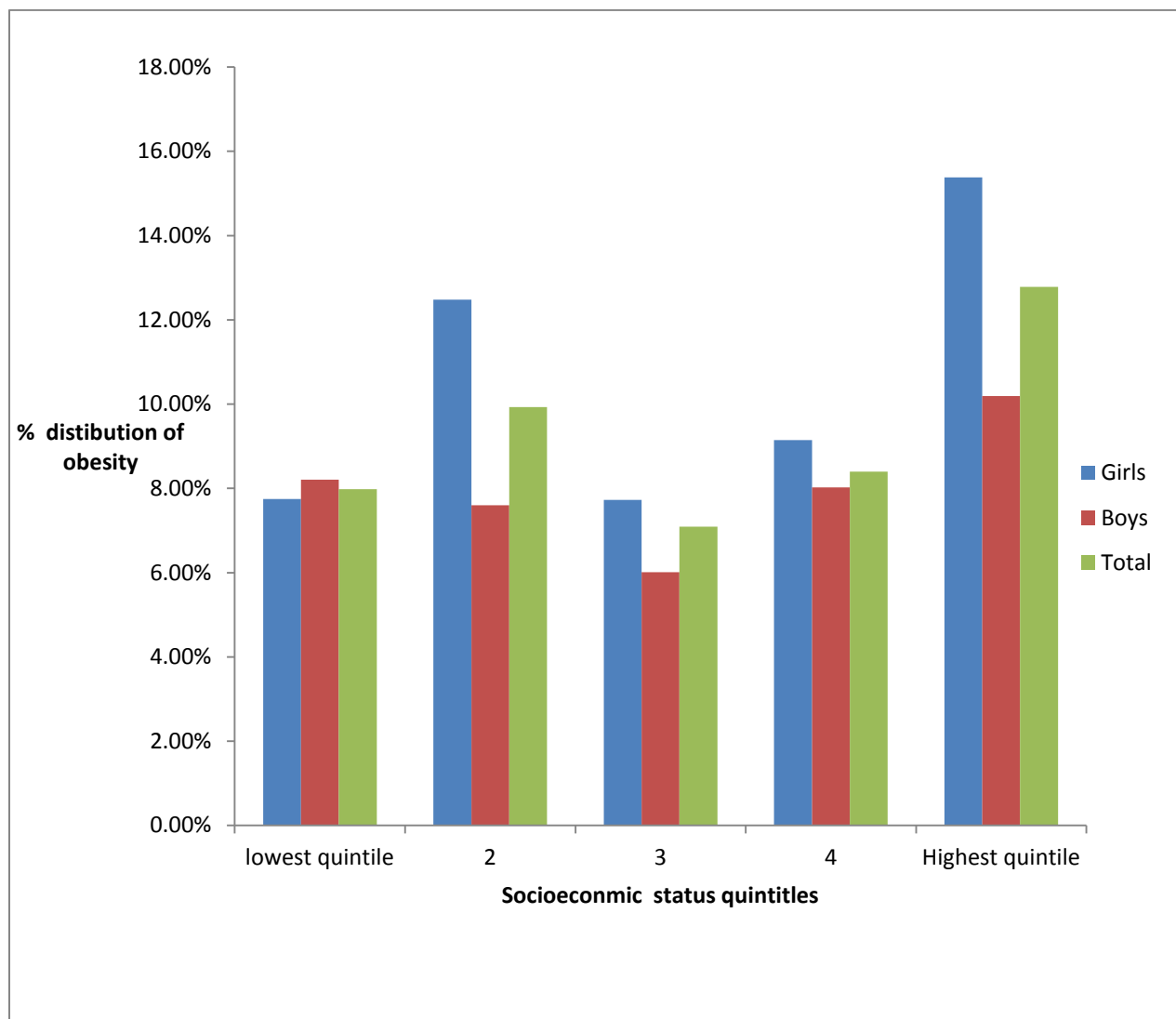
	Grandparent at least attained secondary education (1=yes; 0=No)	5.61%	5.63%	5.62%
	Others at least attained secondary education (1=yes; 0=No)	7.95%	7.80%	7.88%
Household head characteristics				
Sex of Head of household	Household is female (1=yes; 0=No)	73.02%	73.07%	73.05%
Employment status of household head	Household head is employed (1= employed ; 0=otherwise)	35.10%	35.00%	35.05%
Marital status of household head	A household whose head is married (1= head of household is not married; 0=otherwise)	73.02%	73.07%	73.04%
Consumption of readymade foods	A household has consumed readymade foods in the past 30 days (1=reported consumption; 0=otherwise)	0.85%	0.98%	5.32%
Contextual Factors				
Household location: urban	A household located in the urban region (1=located in the urban and 0= located in the rural)	39.90%	39.96%	39.93%
Neighborhood safety	Absence or infrequent occurrence of gangsters' in the neighborhood (1= absence or infrequent gangsters'; 0=otherwise)	28.42%	29.02%	28.72%
Place of birth of the child	The place of birth of the child was a hospital (1=reported hospital and 0=otherwise)	84.04%	82.44%	83.24%
Province	Province of the household residence of the individual (that is nine dummy indicators corresponding to the nine provinces in SA)			

SD represents standard deviation of the continuous variable

3.5.2 Distribution of obesity across different SE groups

As shown in Figure 1, the highest prevalence of obesity was observed among children (boys and girls) from households in the highest SE status (quintile 5), followed by quintile 2. The percentage prevalence of obesity was higher among girls than boys across all quintiles with the exception the first quintile.

Figure 1: Distribution of unstandardized obesity by SES and gender



3.5.3 SE related inequality in childhood obesity

The normalized CI for males and females are given in Table 2. The table entails different but similar results from three different analyses. These three analyses include: unstandardized CI, indirectly standardized for age and gender CI, and indirectly standardized for age and other covariates CI. For the reason of being consistent with the decomposition analysis, all the discussions herewith are based on the third index i.e. -age including other covariates variables. The normalized concentration indices were all positive, indicating that the burden of obesity was more concentrated among children from households with high SES. The overall normalized CI was 0.0638, whereas for girls and boys was 0.0839 and 0.0376 respectively. This estimate suggests that there is greater inequality in the distribution of obesity among girls than boys.

Table 2 Normalized Concentration indices of childhood obesity in South Africa

Normalized concentration indices of obesity by gender			
	Female	Male	Overall
Unstandardized CI	0.0873(0.05)	0.0509(0.06)	0.0724(0.04)
Indirect Standardization with age and gender CI	0.0842(0.05)	0.0377(0.06)	0.0639(0.04)
Indirect standardization with age, gender and other covariates CI	0.0839(0.05)	0.0376(0.06)	0.0638(0.04)

Note: Other covariates include all individual, household and contextual factors. *Standard error is in parenthesis.*

3.5.4 Decomposing SE inequality in childhood obesity

Table 3 and 4 present results from decomposition analysis respectively for girls and boys. The first column displays the partial CI for each of these determinants. A positive (negative) sign indicated that the variable has a pro-rich (pro-poor) distribution. The second column indicates the elasticity of obesity for each explanatory variable. The third and fourth columns report respectively, the absolute and percentage contributions to overall SE inequality in obesity. The absolute contribution is the product of the partial CI and elasticity for each factor. If the absolute contribution factor of a covariate is negative, this can be interpreted as holding all other factors constant, the SE inequality in obesity would be higher if that determinant was not present and vice versa for positive contributions. The percentage contribution was obtained by dividing the absolute contribution by the SE overall income-related inequality listed in table 1.

3.5.4.1 Decomposition of socio-economic inequality in childhood obesity among South African girls

Decomposition of socio-economic inequality in childhood obesity among South African girls is reported in Table 3. SES had a minimal contribution towards SE inequality in obesity among girls. This implies that the inequality observed among girls is explained by other factors rather than SES. Race (33.6%), head of household characteristics (27.5%) and a household located in the urban region (22.6%) contributed greatly to the inequalities. Black (64.1%) race among the categories of race contributed a substantial inequality in obesity. Similarly, household head is employed (16.3%) had the main contribution among household head characteristics.

Table 3: Decomposition of socio-economic inequality in childhood obesity in among South African girls

Socio-economic variables	Concentration index of the covariates(CI)	Elasticity (b)	Contribution towards inequality (CI*b)	Percentage contribution towards inequality
Socio-economic Status	0.593	-0.003	-0.002	-2.3%
Variables at Individual level				
Age	-0.005	-0.634	0.003*	4.0%
Race of child				
white	base	base	base	base
African Black race	-0.078	-0.690	0.054	64.1%
Coloured race	0.212	-0.074	-0.016	-18.5%
Asian/Indian race	0.614	-0.016	-0.010	-11.7%
overall			0.028	33.9%
Illness status of child	0.141	-0.062	-0.009	-10.4%
Variables at Household level				
Family Structure				
Number of household residents	0.050	-0.260	-0.013	-15.4%
Parents of the child live together	0.127	0.100	0.013	15.4%
overall			0.00	0.0%
Caregiver characteristics				
Caregiver of the child				
Mother or father	0.026	-0.033	0.003	3.1%
Grandparents	-0.105	-0.002	0.001	1.0%

others	base	base	base	base
Education of the caregiver				
Mother or father education	0.072	0.048	0.003	4.1%
Grandparents education	0.025	0.022	0.001	0.7%
others	base	base	base	base
Overall			0.007	8.8%
Characteristics of household head				
Head of household is female	-0.058	-0.006	0.000	0.0%
Head of household is employed	0.230	0.060	0.014	16.3%
Head of household is married	0.126	0.071	0.009	10.7%
Overall			0.023	27.5%
Consumption of ready -made foods in the past 30 days	0.364	0.001	0.000	0.0%
Contextual variables				
Household location				
Rural	Base	Base	Base	Base
Urban	0.162	0.117	0.019	22.6%
Place of birth				
Otherwise	Base	Base	Base	Base
Hospital	-0.059	0.079	-0.005	-5.6%
Neighbourhood safety				
Otherwise	Base	Base	Base	Base
Absence or infrequent gangsters'	0.013	0.224	0.003	3.4%
Provinces				
Western cape	0.312	0.057	0.018	21.3%

Eastern cape	-0.246	0.013	-0.003	-3.9%
Northern cape	0.070	-0.011	-0.001	-0.9%
Free state	0.021	-0.014	0.000	0.0%
KwaZulu-Natal	-0.019	0.029	-0.001	-0.7%
North West	-0.063	0.025	-0.002	-1.9%
Gauteng	0.137	-0.046	-0.006	-7.6%
Mpumalanga	0.013	-0.001	0.000	0.0%
Limpopo	base	base	base	base
overall			0.005	6.3%

3.5.4.2 Decomposition of socio-economic inequality in childhood obesity among South African boys

The Decomposition of socio-economic inequality in childhood obesity among South African boys is presented in Table 4. The result showed that socio-economic status (224.0%) was the biggest contributor followed by other factors including age (34.9%), race of the child (-24.9%), family structure (-22.7%) household characteristics (38.1%) and province (-17.8%). The discussion was confined to covariates other than age since age is not regarded as a variable open to policy (53). In terms of household head characteristics, the key category was household head is employed; whose contribution towards inequality was highest is greater than other categories. Furthermore, coloured race (-10.9%) among other categories of the race of the child contributed most to the inequality.

Table 4 Decomposition of socio-economic inequality in childhood obesity among South African boys

Socio-economic variables	Concentration index of the covariates(a)	Elasticity (b)	Contribution towards inequality (a*b)	Percentage contribution towards inequality
Socio-economic Status	0.549	0.153	0.084	224.0%
Variables at Individual level				
Age	-0.012	-1.114	0.013	34.9%
Race of child				
White race	base	base	base	base
African Black race	-0.088	0.022	-0.002	-5.1%
Coloured race	0.259	-0.016	-0.004	-10.9%
Asian/Indian race	0.757	-0.004	-0.003	-8.9%
Overall			-0.009	-24.9%
Illness status of child	0.016	-0.015	0.000	-0.6%
Variables at Household level				
Family Structure				
Number of household residents	0.052	-0.080	-0.004	-11.1%
Parents of the child live together	0.158	-0.028	-0.004	-11.6%
overall			-0.008	-22.7%
Caregiver characteristics				
Caregiver of the child				
Mother or father	0.047	0.102	0.003	7.6%
Grandparents	-0.150	-0.015	0.002	4.8%
other	base	base	base	base
Education of the caregiver				
Mother or father education	0.079	-0.024	-0.002	-5.2%

Grandparents education	-0.024	0.019	0.000	-1.2%
others	base	base	base	base
overall			0.003	6.0%
Characteristics of household head				
Head of household is female	-0.073	-0.036	0.003	7.0%
Head of household is employed	0.232	-0.038	-0.009	-23.3%
Head of household is married	0.162	-0.051	-0.008	-21.8%
overall			-0.014	38.1%
Consumption of ready -made foods in the past 30 days	0.119	0.012	0.001	3.8%
Contextual variables				
Household location				
Rural	Base	Base	Base	Base
Urban	0.140	0.025	0.004	9.5%
Place of birth				
Otherwise	0.026	-0.056	-0.001	-3.9%
Otherwise	Base	Base	Base	Base
Hospital	0.026	-0.056	-0.001	-3.9%
Neighbourhood safety				
Otherwise	-0.037	0.044	-0.002	-4.3%
Otherwise	Base	Base	Base	Base
Absence or infrequent gangsters'	0.013	0.224	0.003	3.4%
Provinces				
Western cape	0.251	0.023	0.006	15.4%
Eastern cape	-0.227	0.047	-0.011	-28.2%
Northern cape	0.041	-0.009	0.000	0.0%
Free state	0.003	-0.022	0.000	-0.2%
KwaZulu-Natal	-0.022	0.086	-0.002	-4.9%
North West	0.003	0.012	0.000	0.0%
Gauteng	0.095	-0.007	-0.001	-1.7%
Mpumalanga	0.026	0.025	0.001	1.8%

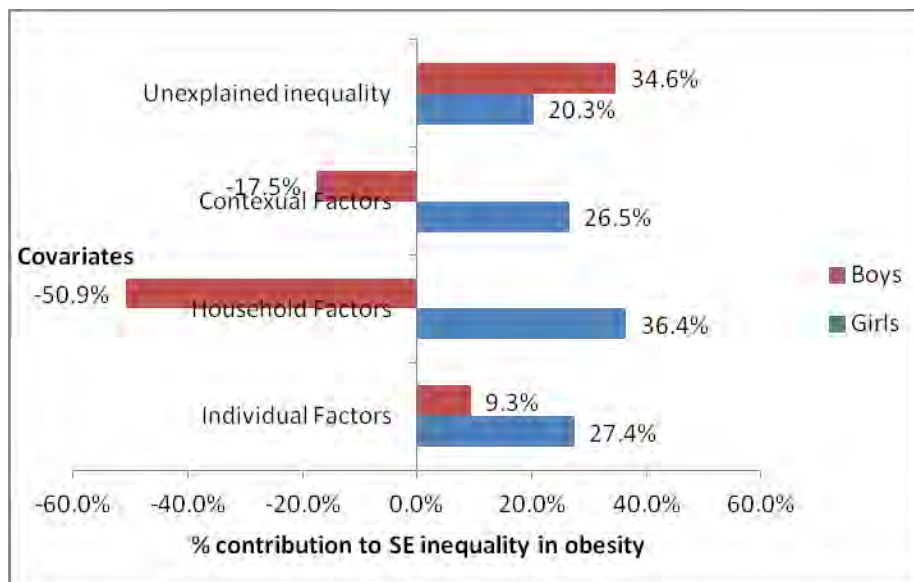
overall	-0.007	-17.8%
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3.5.4.3 Comparison among boys and girls

In the decomposition analysis, differences and similarities among girls and boys are observed. The analyses among boys and girls showed that employed household head and race were among the greatest contributors to SE inequality in obesity. Majority of the SE inequalities in obesity observed among boys are explained by the direct SES (224.0%) unlike those among girls (-2.3%). These differences are due to the large elasticity of obesity with respect to SES in boys compared to girls as seen in Table 3 and 4. The differences observed among boys and girls in terms of percentage contribution for age, province and household location were also due to variation in the elasticities. Family structure contributed 0% and -22.7% respectively among girls and boys. The zero contribution of family structure among girls was influenced by a negative (household size) and positive (Parents of the child live together) of the variables under this category. Other variables included in the analysis but had minimal contribution include: neighbourhood safety, illness status, consumption of readymade food, and lastly caregiver characteristics.

Figure 2 is a graphical representation of the decomposition of socio-economic inequality in childhood obesity with the percentage contribution from individual, household and contextual categories. As seen from the graph, household factors were the greatest contributor to the SE in obesity whereas contextual and individual factors are more less the same. Unexplained inequality is that part of inequality that is not explained by chosen determinants. The percentage contribution of the unexplained inequality was 20.3% and 34.6% respectively for both boys and girls. This means that the decomposition model functioned well in explaining SE inequality in obesity.

Figure 2: Percentage contribution towards SE inequality in childhood obesity



3.6 Discussion

Analysis of 2012 SA-NIDS of children from ages 2 to 14 years shows evidence of a reversed social gradient, that is higher SE position has been shown to be associated with higher prevalence of obesity among SA children. These results, confirm findings from previous studies in SA (14,19,20,54) and add to similar evidence from other LMICs (LMICs) (17,35,55,56) that show that obesity tends to increase with higher SES. Noting that in countries undergoing a nutritional transition such as SA and Brazil (57–59), while obesity might initially be more prevalent in the higher SE groups, as the transition progresses, the obesity burden shifts from the rich to the poor (17,60,61). Further studies are needed to monitor the changes in trends of obesity prevalence across the different SE groups and adapt public health and clinical practice accordingly.

To our knowledge, this is the first study to formally present CI of female and male obese children in South Africa. The CI of obesity in girls ($CI=0.1736$) was higher than that of boys ($CI=0.0584$), indicating that there were more inequalities in the distribution of obesity for girls across SES than boys. These findings are consistent with findings from a study from Ireland, middle income countries (62–64) and South Africa (6,65,66) that found greater inequalities among girls compared to boys. The gender differences may be attributed to onset of puberty, a period where girls acquire more body fat compared to boys. Physical activity may also influence gender differences. A study found South African boys had higher levels physical activities than girls, and in both genders, low levels of physical activity were associated with overweight and obesity (18). Recently, Feeley et al. (2013) found an association between soft drink consumption and increased BMI and fat mass in boys but not girls. This study suggests that

dietary habits may contribute to gender differences observed between South African boys and girls.

In order to understand the determinants of these SE inequalities in obesity in both boys and girls, the study uses the decomposition by CI method. The decomposition analysis results suggest that the determinants of SE inequalities in obesity vary considerably across a range of individual, household and contextual factors and by gender of child. This may imply that efforts to control obesity cannot rely on solely on direct action to make children eat more healthily and be more physically active but requires engagement of all sectors of society to generate effective responses for obesity prevention and control. Generally, the main contributors of these inequalities among females and males are household factors. These findings are consistent with other studies ((25,32,35) that have found household characteristics to contribute to obesity inequalities. In boys and girls, household head characteristics such as is employment status of household head is one of the main household level factors contributing to inequality. The results are in line with previous studies that have found employment status to be associated with obesity among children (68,69) through influencing the purchasing capacity of the households accompanied by affordability of sedentary recreation gadgets, motorised transport and calories availability (70).

Apart from household factors, race of the child was another factor that contributed greatly to the inequalities in obesity. The link between race and obesity, has been observed in a previous South African study of grade 9 to 11 students that found that male African Black youth had the lowest rates of obesity and overweight whereas among girls, Coloured had the lowest rates

compared to African Black and White children (5). Similarly, a recent study among confirmed that female gender (especially Black/African and White ethnicity) as a key determinant of higher obesity risk in South Africa (71). The suggested reason for why SA black women are at risk is related to body image and a preference for a large size (72).

Furthermore, place of residence is a high contributor to inequalities among the girls. Girls living in households located in urban areas contributed greatly to inequalities in obesity. This association has been supported by empirical literature that has found children living in an urban area to be at risk for obesity or overweight (18,20). In addition, a South African study demonstrated that urbanization is an important determinant of obesity in South Africa(71) moreover urbanization has been linked to an increase in dietary fat intake (associated with increased prevalence of obesity)(73).

In considering our results and their policy implications, it is worth stressing that the cross-sectional nature of the available data, does not attempt to identify causal pathways. This means that while vital determinants of SE inequalities of childhood obesity have been identified in this paper, further work (longitudinal study) is required before direct policy interventions based on the findings should be pursued. Another limitation of the study was lack of data on the likely determinants of childhood obesity such as physical activity, community recreation centres. Lastly in the decomposition analysis the linear regression model was used despite the fact that health outcome was binary in nature.

3.7 Conclusion

This paper provided an analysis of the SE inequalities in obesity amongst South African children. The results of this study are consistent with evidence from other LMICs (Brazil) and HICs (United States) that suggest that obesity will in the initial period follow a reverse social gradient and thereafter increasingly be associated with the poorer. Therefore, there is a need for continuous surveillance to monitor changes in obesity epidemic over time across SES. In addition, the results of this study suggest the need for further research to better understand the underlying determinants contributing to the gender differences in childhood obesity in SA. Finally, notwithstanding the cross sectional and other limitations, the findings suggest that both childhood obesity prevalence and inequalities are complex issues that may require coordinated policy and programmatic interventions at individual, household and contextual level.

3.8 List of Abbreviations

SA South Africa

SE Socio-economic

SA-NIDS South African National Income Dynamics Survey

IOTF international Obesity Task Force

BMI Body Mass Index

CI Concentration Index

SES socio-economic Status

HIC High Income Country

MIC Middle Income Country

NCDS Non communicable diseases

3.9 Declarations

3.9.1 Ethics approval and consent to participate

This study was a secondary analysis based on publicly available data sets that were collected after the appropriate ethics approval by the Commerce Faculty Ethics Committee at the University of Cape Town. Despite the fact that there was no special ethical issue to address, permission to use the data set was obtained from DataFirst at University of Cape Town.

3.9.2 Consent of publication

Before publishing this paper, permission was obtained from University of Cape Town

3.9.3 Competing interests

The author declares that they are no competing interests

3.9.4 Author's contribution

NB, who conceived the idea for the study and its design, was also responsible for data analyses and preparation of the manuscript.

3.9.5 Author's information

NB is a Master's student in Public Health, specializing in Health Economics at the University of Cape Town

3.9.6 Funding

None

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3.10 End note

¹ The use of the terms 'Black African', 'White', 'Coloured' and 'Asian' reflects a statutory stratification of the South African population in terms of the former Population Registration Act. The use of these terms does not imply the legitimacy of this racist terminology

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4 PART D: POLICY BRIEF

August 2016

Socio-economic inequalities of childhood obesity in South Africa

To what extent do socio-economic inequalities in childhood obesity exist and what determinants of childhood obesity are driving these inequalities in South Africa?



This policy brief is based on a study that assessed the extent of socio-economic inequalities in childhood obesity using a nationally representative South African Survey: National Income Dynamics Survey (NIDS). In addition, the study identified the determinants of obesity driving these inequalities. This study was submitted as a mini-dissertation by Brenda Nakimuli to the Health Economics unit, Faculty of Health sciences at the University of Cape Town under the supervision of Dr. Olufunke Alaba and Veloshnee Govender.

4.1 Executive summary

Childhood obesity is a public health concern. The devastating consequences of childhood obesity are not only limited to physical but also psychological wellbeing and in turn may lead to non-communicable diseases (NCDs) and which have long-term economic consequences. In order to contribute useful insights for developing effective obesity policy and programme interventions, this study assessed socioeconomic (SE) inequalities related to childhood obesity in South Africa.

This study found out that the burden of obesity is concentrated among children from higher SE groups, implying that children who belong to a high SE group are at increased risk of obesity. The study also identified the household level factors (i.e. characteristics of household head in both boys and girls) compared to other contextual and individual factors are the major determinants of obesity that are driving these differences in the burden of obesity across different SE groups. SES was the main contributor to SE inequality in obesity among boys followed by race (i.e. Coloured), and age whereas a household location (i.e. urban region) and race (i.e. African Black) were the main contributors amongst girls. These findings suggest that there is a continuous need for surveillance of obesity in children over time across SES especially in low and middle income countries. Finally, the results suggest that both childhood obesity and inequalities are complex issues with different underlying determinants that may vary by SES, gender and that require coordinated policy and programmatic interventions at the individual, household and contextual level.

4.2 Introduction

Obesity has become a public health concern in low- middle income countries (LMICs) especially among those undergoing economic transition such as South Africa (SA) (Ng et al. 2014). This is because economic growth fuels industrialisation and urbanization where high-calorie consumption

Box 1: what is obesity?

Obesity is a malnutrition disorder that is characterized by abnormal or excessive fat accumulation which is positively associated with adverse effects on health and wellbeing of an individual (World Health Organization 2015a)

is sparked off by readily available low priced high calorie foods (Monteiro et al. 1995). This nutrition transition is followed by limited time and fewer opportunities for recreational exercise (Popkin 1994). In SA, the

prevalence rates of childhood obesity are said to be at par with that of many industrialised nations (e.g. USA), ten years ago and amongst the highest in Africa (Reddy et al. 2009). Obesity in children in addition to carrying health and psycho-social risks associated with NCDs (Steinberger 2003; Mathur et al. 2007; Lee 2007; Hannon et al. 2005; Ebbeling et al. 2002; Strauss 2000; Karnik & Kanekar 2012) also often leads to adult obesity and its associated morbidity and mortality (Lobstein et al. 2004; Power et al. 1997). The analysis of SE inequalities related to childhood obesity may identify entry points

for targeted obesity prevention policies and interventions. The purpose of this policy brief is to

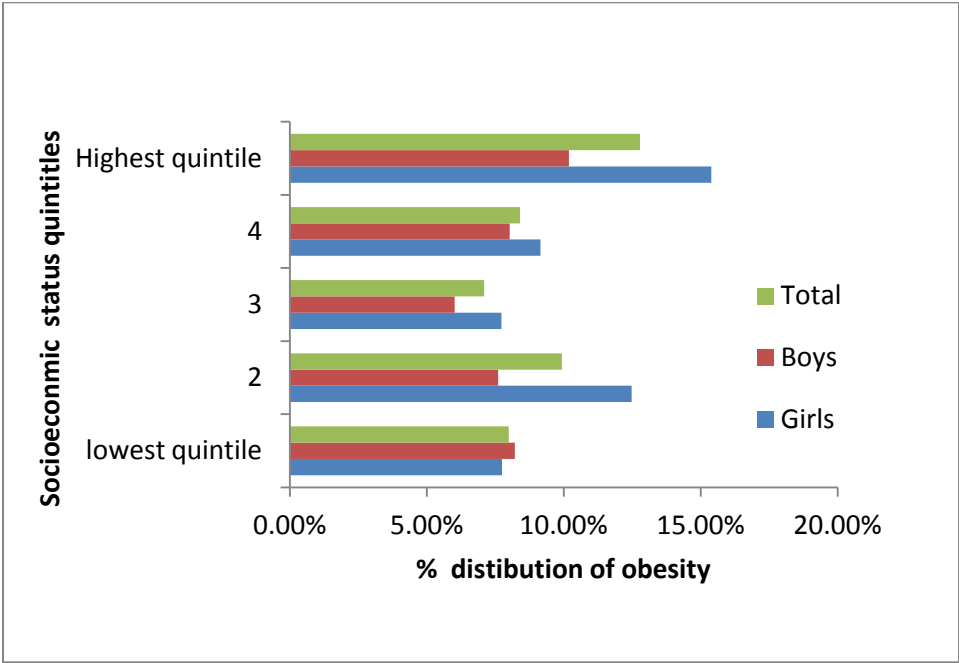
Box 2: what are socio-economic inequalities in obesity? Socio-economic inequalities in obesity refers to differences in the distribution of obesity that is related to individual socio-economic status in the society

present the extent of SE inequalities related to childhood obesity (children from the age 2 to 14 years) in SA. Despite the fact that measuring SE inequalities in health is urgently needed for education, and advocacy among the general public and decision makers, these measures may not be sufficient to bring about a sustainable change on their own (Victora et al. 2003). Therefore, for more effective policies to be developed, unraveling and quantifying the determinants of SE inequalities in childhood obesity is recommended (Uthman 2009). Therefore, this policy brief examines this issue using the 2012 National Income Dynamics Survey (NIDS).

4.3 Are there any differences in the distribution of obesity across the different SES groups?

Figure 1 presents the distribution of obesity across different SE groups and gender. Obesity is greater among children with higher socio-economic status. Moreover, this distribution was greatest among girls compared to that among boys across almost all SE quintiles.

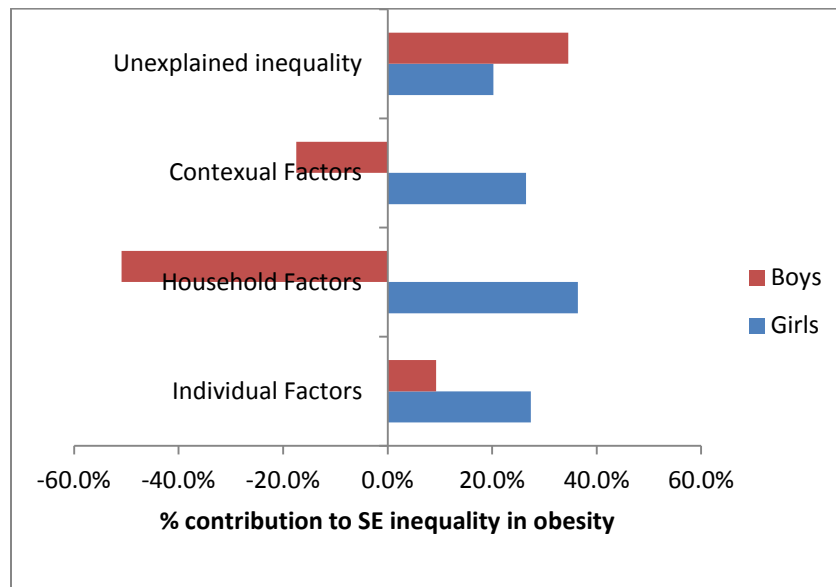
Figure 1: showing percentage distribution of obesity by socioeconomic status



4.4 Socioeconomic inequalities in childhood obesity and their determinants

The concentration index (CI) was the method used to measure SE inequalities in childhood obesity. The study found a positive CI in both boys and girls. A positive CI means that the burden of obesity is concentrated among the rich households. Furthermore, the CI was greater among girls compared to boys implying that the burden of obesity is greater among girls from rich households compared to boys from rich households (greater SE inequalities among girls compared to boys). Upon further investigation, the factors that contribute to SE inequalities are an interplay of individual, household and contextual level factors. The greatest contributors of SE inequality in obesity were household level factors in both boys and girls as shown in Figure two. The positive percentage contribution on the graph can be interpreted as holding all other factors constant, the SE inequality in obesity would be lower if that determinant was not present and vice versa for negative contributions. When factors at household level were examined, it was found that household head characteristics (i.e. employment and marital status) in both boys and girls contributed the highest towards SE inequality. The factors at individual level that greatly contributed to the SE inequality in obesity was race in both genders. At contextual level, household location (household located in an urban region) and province contributed to SE inequality in obesity respectively among both boys and girls.

Figure 2: Percentage contribution to SE inequality in childhood obesity



4.5 Policy Recommendations

The results of the study have significant and key policy messages for South Africa and other LMICs:

- ❖ Continuous surveillance of obesity among children across SE groups is needed in LMICs
- ❖ When developing strategies to reduce SE inequalities in obesity among children, there is need to pay attention to gender since underlying determinants might differ requiring differentiated and targeted strategies.
- ❖ The findings suggest that SE inequalities in obesity are complex issues that require coordinated policy and programmatic interventions at individual, household and contextual level. However, because of the cross-sectional nature of the study, a longitudinal study is required for more targeted interventions taking account of the influence of individual, household and contextual level with respect to gender.

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5 Part E: APPENDICES

5.1 Appendix 1: International journal for Equity in Health - Guide for authors

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Article within a journal by DOI

Slifka MK, Whitton JL. Clinical implications of dysregulated cytokine production. *Dig J Mol Med.* 2000; doi:10.1007/s801090000086.

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Book chapter, or an article within a book

Wyllie AH, Kerr JFR, Currie AR. Cell death: the significance of apoptosis. In: Bourne GH, Danielli JF, Jeon KW, editors. International review of cytology. London: Academic; 1980. p. 251-306.

OnlineFirst chapter in a series (without a volume designation but with a DOI)

Saito Y, Hyuga H. Rate equation approaches to amplification of enantiomeric excess and chiral symmetry breaking. Top Curr Chem. 2007. doi:10.1007/128_2006_108.

Complete book, authored

Blenkinsopp A, Paxton P. Symptoms in the pharmacy: a guide to the management of common illness. 3rd ed. Oxford: Blackwell Science; 1998.

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Organization site

ISSN International Centre: The ISSN register. <http://www.issn.org> (2006). Accessed 20 Feb 2007.

Dataset with persistent identifier

Zheng L-Y, Guo X-S, He B, Sun L-J, Peng Y, Dong S-S, et al. Genome data from sweet and grain sorghum (*Sorghum bicolor*). GigaScience Database. 2011. <http://dx.doi.org/10.5524/100012>.

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UNIVERSITY OF CAPE TOWN
Faculty of Health Sciences
Human Research Ethics Committee



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Website: www.health.uct.ac.za/fhs/research/humanethics/forms

20 October 2015

HREC REF: 645/2015

Dr O Alaba
Public Health & Family Medicine
Falmouth Building

Dear Dr Alaba

PROJECT TITLE: DECOMPOSITION OF SOCIOECONOMIC INEQUALITIES IN CHILDHOOD OBESITY PREVALENCE IN SOUTH AFRICA (MPH Candidate – Ms B Nakimuli)

Thank you for your response to the Faculty of Health Sciences Human Research Ethics Committee received on 16 October 2015.

It is a pleasure to inform you that the HREC has **formally approved** the above-mentioned study.

Approval is granted for one year until the 30th October 2016.

Please submit a progress form, using the standardised Annual Report Form if the study continues beyond the approval period. Please submit a Standard Closure form if the study is completed within the approval period.

(Forms can be found on our website: www.health.uct.ac.za/fhs/research/humanethics/forms)

Please quote the HREC REF in all your correspondence.

We acknowledge that the student, Brenda Nakimuli will also be involved in this study.

Please note that the ongoing ethical conduct of the study remains the responsibility of the principal investigator.

Yours sincerely

Signed

PROFESSOR M BLOCKMAN

CHAIRPERSON, FHS HUMAN RESEARCH ETHICS COMMITTEE

Federal Wide Assurance Number: FWA00001637.

Institutional Review Board (IRB) number: IRB00001938

This serves to confirm that the University of Cape Town Human Research Ethics Committee complies to the Ethics Standards for Clinical Research with a new drug in patients, based on the Medical Research Council (MRC-SA), Food and Drug Administration (FDA-USA), International Convention on Harmonisation Good Clinical Practice (ICH GCP), South African Good Clinical Practice Guidelines (DoH 2006), based on the Association of the British Pharmaceutical Industry Guidelines (ABPI), and Declaration of Helsinki (2013) guidelines.

HREC 645/2015

The Human Research Ethics Committee granting this approval is in compliance with the ICH Harmonised Tripartite Guidelines E6: Note for Guidance on Good Clinical Practice (CPMP/ICH/135/95) and FDA Code Federal Regulation Part 50, 56 and 312.